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THROUGH THE EYES OF THE EDITOR

Victor H. Sears discusses the selection and management of posterior teeth and relates them to other phases of denture construction. He specifies what he considers to be essential requirements of posterior teeth. There will be little disagreement with most of the essential requirements he describes, but it is likely that some of them will not receive universal approval. He recommends the use of porcelain teeth opposed by plastic teeth in order to secure the advantages of both materials. This is a relatively new idea, and it is worthy of careful clinical testing. It should be kept in mind, however, that the wearing away of plastic teeth results primarily from the abrasion of the teeth by food. By comparison, the amount of plastic tooth substance lost from friction with an opposing tooth is relatively small if that tooth surface is smooth. It is apparent that the loss of tooth substance will be reduced if wear occurs on the teeth of only one denture. His description of the technique for arranging the posterior teeth should be helpful to those attempting to follow his concept of occlusion. He sets up definite rules for tooth placement which have stabilization of the dentures by mechanical means as the objective. One of the most controversial parts of his article relates to the use of "occlusal pivots." There can be little doubt of the disadvantages of excessive pressures in the front of the mouth, especially with complete dentures. However, there is still some question about the possibility of pulling the condyles to a different vertical level when the change must depend upon *denture tooth* contacts. It would seem more logical that the dentures would shift slightly on their respective foundations to give an illusion of change of condylar position. Also, it should be apparent that a protrusion of the mandible into a forward eccentric position would relieve the built-in premature molar contact and give the illusion of having pulled the condyles down. The fact that essentially flat occluding surfaces are recommended seems to be significant.

Frank H. McKevitt discusses the problems related to locating the plane of occlusion and the distance between the residual ridges. He shows evidence that changes in the bones involved can either increase or decrease this distance. An adequate diagnosis is shown to be essential, and the treatment plan must be developed in relation to the changes in the bones. The term "interridge crestline space" (or distance) offers interesting possibilities for further corelation with facial dimensions. He recommends procedures which involve measurements that are simple to make and which could be most helpful.

Meyer M. Silverman discusses current concepts of jaw relations and occlusion and points out what he considers to be fallacies in them. He criticizes many of the principles being taught in dental schools, he deplores the "confusion" existing in terminology, and he criticizes some more or less accepted definitions of terms. He suggests that his methods will eliminate or obviate the misunderstanding and confusion and solve all of the problems. Unfortunately, the problems and their solutions are not that simple. He has included many statements which are critical and even derogatory to concepts and definitions which differ from his interpreta-

tions. He deplores the confusion regarding factors of occlusion and attempts to substitute his ideas for those which have been found by many to be valid. This would not be too serious if the criticisms were applied fairly. He has taken statements out of context and has used them to support his claims. For example, this was done in his comments about rest position and interocclusal distance. He criticizes both the term "centric relation" and its definition. Certainly he has the right to define a term as he understands it, but when he suggests that certain terms, which have been used and understood by the profession over a long period of years, be eliminated from the literature, he is taking on a rather large responsibility. For example, when he suggests that the term "centric maxillomandibular relation" be substituted for the term "centric relation," it is difficult to see the advantage. "Centric relation" has always meant the relation of the mandible to the maxillae under certain conditions. What is the advantage of adding the word maxillomandibular? The "confusion" regarding centric relation involves the differences in concept regarding it and in the methods of recording it. There are some who visualize centric relation as a two dimensional relationship and others who see it as a three dimensional relationship. Even these can be reconciled if an honest appraisal of each concept is made. The question seems to be: should centric relation records be made with a minimum closing pressure or with a maximum closing pressure? The answer lies in the objectives of the dentist making the records, i.e., does he want the teeth to meet evenly when they first contact, or does he want them to meet evenly under heavy closing pressures? These questions have not been answered satisfactorily as yet. Each of us has his own opinion, but which is correct? No doubt the procedures recommended will produce satisfactory dentures for *some* patients, but clinical experience has shown that *some* patients require balanced occlusion in eccentric positions as well as in centric position. Some patients can adapt themselves to restrictions in mandibular movement and others cannot. The acceptance of the "resultant biting point" for establishing centric occlusion to the exclusion of consideration for centric relation is certainly open to question. The occlusal readjustments of the dentures in the mouth after their insertion probably provide the clearances that make the dentures usable.

Krishan K. Kapur and A. Albert Yurkstas point out what they believe to be a controversy regarding interocclusal records, and they classify the various recording methods. The classification is very interesting, but it could be developed even further. In order to test the accuracy of three characteristic methods, they depended upon a series of records made for each subject which were compared in regard to duplicability. The fact that a record could be duplicated would not *necessarily* indicate that the records were correct. They used many procedures which were designed to eliminate human errors. It is interesting to note that variations were found in records made by all the methods tested. They point out that the errors were relatively small and indicate that the small error is not clinically significant. This does not seem to be borne out in clinical practice. A small error is difficult to detect, but a small error can be the source of much discomfort to patients, especially if cusp teeth are used. Larger errors may be detected easily and corrected, but sometimes small errors are difficult to locate. They point out the fact that certain methods are more accurate than others. for a given type of mouth condition. This has clinical significance and could be interpreted as a suggestion that the method be varied with the type of ridge and the thickness of the mucosal covering of the bone.

Ulf Posselt discusses the terminal hinge movement of the mandible and describes his experiments relating to it. His conclusion that the mandible does have a hinge axis closure that can be recorded is qualified by a recognition of the practical difficulties of recording and using the hinge axis. The fact that the hinge axis *can* be recorded does not imply that it *will* be recorded in every instance.

Isaih Lew describes the use of mucosal inserts for retaining maxillary dentures. The procedure is quite radical in that it involves the development and maintenance of artificial openings or pockets in the oral mucosa. The technical procedures involved are not as extensive or complicated as for the usual

implant dentures. The objectives of the two procedures are different but both involve considerable patience on the part of the patients. While this technique may be helpful in some instances, it cannot be a routine procedure. Unfortunately, many of the conditions which cause trouble with mucous membrane supported dentures are apparently unfavorable for mucosal inserts. Considerably more clinical testing must be done before the procedure can be taken out of the experimental class.

Lawrence A. Weinberg discusses the distribution of the forces of occlusion as they are modified by inclined plane contacts, relative location of tooth contacts, and the angles of jaw closure. These factors are developed primarily with consideration for their effects upon periodontal tissues, but they may be applied equally to the occlusion of dentures. The torques developed by unfavorable tooth contacts are the cause of much discomfort to patients wearing dentures, because the damage to the supporting tissues is immediate and gets progressively worse until bone resorption produces an accommodating occlusal harmony. It is obvious, however, that these forces are most destructive when food is *not* present in the mouth.

Philip Manners describes a technique for removing porcelain or acrylic resin jacket crowns without damage to the crowns. The procedure can make a difficult and tricky procedure seem relatively easy.

Marjorie L. Swartz and Ralph W. Phillips report their study of the adaptation of various veneers to gold castings. As would be expected, porcelain baked on gold showed the least leakage. It is interesting that radioisotopes were used to locate the discrepancies. This was a very severe test, and it would seem to point the way toward the solution of the problem of discoloration of veneers.

Louis C. Schultz reviews the progress being made toward the solution of the problem of dental caries. In time, the tremendous amount of effort being exerted in this direction will certainly find the way to control dental caries and show the way to eliminate this disease, the most prevalent of all. However, it is likely that the effectiveness of the most effective method will still be dependent upon the cooperation of people in making use of it. To know the method is not enough; it must be used.

Charles M. Stebner reports his observations about some of the materials being used in the general practice of dentistry. It is interesting to contemplate the changes that are occurring in this direction. Considered on a day-to-day basis, there seems to be little change, but a review such as this points out the need for constant vigilance and study of current literature, or progress will pass us by.

Rex Ingraham reports his evaluation of the cutting instruments used for the preparation of teeth for restorations. He urges that the profession be prepared to accept the new instruments but to accept them wih caution, intelligence, and judgment. The chief objective of new equipment should be the accomplishment of a better preparation with less danger to the pulp rather than the reduction of operating time. The intelligent use of new equipment should provide both.

—Carl O. Boucher

Editorial Council Announcement

As chairman of the Editorial Council, it is my pleasure to make this important announcement to the readers of THE JOURNAL OF PROSTHETIC DENTISTRY. The Editorial Council has arranged with the publishers to increase the text material in the JOURNAL by thirty-two pages in each issue, making a total increase of 192 pages per year. This additional material will provide further coverage in the field of dentistry with as many of these extra pages as practicable being devoted to subjects relating to operative dentistry.

The JOURNAL, which is now completing its seventh year of service to the dental profession, has a circulation of approximately thirteen thousand copies of each issue. This means that, not counting the issues going to dental schools and other institutions, nearly thirteen thousand individual dentists want to read THE JOURNAL OF PROSTHETIC DENTISTRY and are subscribers. Probably not more than two hundred, or three hundred at the most, of these readers limit their practices to complete denture construction, or even to removable prosthetic appliances which would include partial dentures. This means that well over twelve thousand subscribers are general practitioners in dentistry and are interested in doing good work in all of its phases. It also indicates that our readers are men and women of high ideals and intellectual levels and that they are just as important to our progress as are our contributors, staff, and publishers.

As the over-all picture of dental procedures changes, there is such a fine line of distinction between operative dentistry and prosthetic dentistry that it is hardly discernible. The preparation of a tooth for a single crown and the impression and the fabrication of the restoration are not significantly different if the tooth is to be used as an abutment for a fixed or for a removable prosthesis, or if it is to be restored as an individual tooth. Is this prosthetic dentistry or is it operative dentistry? Rather than quibble over the answer, beginning with the January, 1958 issue, THE JOURNAL OF PROSTHETIC DENTISTRY will include enough significant, new, and important material in the field of operative dentistry to supply our readers with a noteworthy additional service. The Editorial Council sincerely believes that the subscribers will be grateful.

LOUIS S. BLOCK, D.D.S.
Chairman, Editorial Council

THE SELECTION AND MANAGEMENT OF POSTERIOR TEETH

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THE SELECTION OF POSTERIOR teeth comprises not only size and color, but also design and material, or combination of materials. Management includes not only arrangement, but also the alteration of form during and after the arranging when indicated.

In connection with the selection and management of posterior teeth, there are two other closely related matters, jaw relations and articulator adjustments, which need some consideration. Actually, then, there are four related phases of the tooth problem here: selection of the posterior teeth, jaw relations, articulator adjustments, and management of the posterior teeth. These phases will be discussed where they overlap.

The results obtained through intelligent handling of these four phases of the posterior tooth problem will more than justify any added effort. After one grasps the principles involved, their application is neither difficult nor overly time-consuming.

ESSENTIAL REQUIREMENTS OF POSTERIOR TEETH

After thirty-five years of designing and testing posterior teeth for dentures,[1] we should know the essential requirements pretty well. Several features have been incorporated in various designs since the need for special occlusal forms became recognized. But it was only recently that teeth were designed to meet all of the recognized requirements. This is important, because only with appropriate tooth forms is it possible to construct dentures in harmony with the known mechanical principles.

Most discussions of tooth arrangement concentrate on appearance and on tilting the occlusal surfaces to maintain contact during centric and eccentric movements of the articulator. Much of the literature, both in the dental journals and in the manufacturers' instructions, seems to imply that there is little more than this to the problem.

Of course, these are important considerations, but there are others. It is these other considerations, having especially to do with leverage and with the action of the inclined plane as well as with the refinements after processing, that make the procedure more interesting and the dentures more serviceable and comfortable in the patient's mouth. The principles are dealt with more fully elsewhere,[2] but they will be considered in the present discussion as we proceed with the sequence of steps.

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In the matter of characteristics of posterior teeth, we should not overemphasize any one feature. Rather, we should set up ideal specifications and attempt to meet all of them as nearly as possible, with special attention to the most important requirements. Stability, comfort, chewing efficiency, appearance, conservation of supporting structures, and ease of obtaining correct arrangement are all important factors. No single one should be stressed at the expense of the over-all requirements.

Specifications have been set up by two designers of artificial teeth. In 1929, Myerson[3] published five specifications. The writer,[4] in 1922, mentioned four requirements without tabulating them as "specifications." In 1927,[5] he stated these in different words. In 1931,[6] he set up ten specifications, and in 1952,[7] seventeen. In 1950, the writer[8] also pointed out ten essential differences between the requirements for natural and for artificial teeth.

These "requirements," "specifications," and "essential mechanical differences" have remained unchallenged in the dental literature and are supported by large-scale clinical evidence. They were generally known and accepted, yet until the present instance no structure which adequately met the needs had been offered to the profession.

One special feature of tooth form might be made at this point. Along with our concern over the occlusal surfaces of the teeth, some prosthodontists have been laying stress, quite properly, on the need for teeth of such bulk that their lingual and buccal surfaces will make "natural" contact with the tongue and cheeks. Such buccal and lingual contacts not only feel right to the patient but also tend to promote denture stability and aid in speech and chewing.

When the lingual surfaces of the teeth are placed properly, there is no excess space between the tongue and teeth, nor crowding by the teeth to interfere with speech or chewing.

In the case of "anatomic" as well as in that of some of the "special" tooth forms, this requirement of adequate buccolingual breadth to make "natural" contact with tongue and cheek has been compromised, because the designers felt that teeth broad enough for this would necessitate occlusal surfaces too great to pass readily through the food. And so "anatomic" and "special" forms were designed narrow enough to pass through the food, but too narrow to place the buccal and lingual surfaces properly. Avoidance of this unnecessary and excessive narrowing is part of the discussion of leverage (Figs. 1, 2, and 3).

BUCCOLINGUAL LEVERAGE

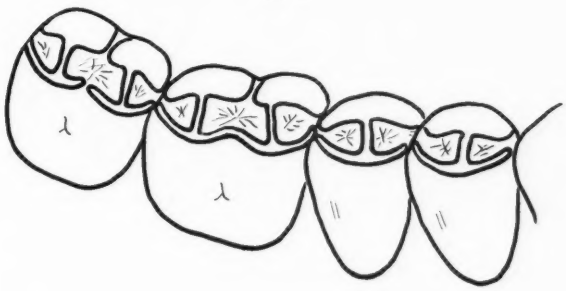
With a growing awareness by the profession of the evils of teetering denture bases, the teeth were set well to the lingual side of the residual ridge. This expedient centralizes the load and thus minimizes the danger of side-to-side teetering. Buccolingual leverage was, then, another factor influencing tooth designers to make posterior teeth narrower.

Narrowing of the teeth permits us to set teeth further lingually without crowding the tongue, but it presents the disadvantage of increasing the horizontal gap in the buccal vestibule. This gap produces an unpleasing esthetic effect, tends to cause the accumulation of food in the vestibule, and sometimes produces an

unpleasant sound, as air escapes along the buccal surfaces of the teeth in speaking. It also permits the cheeks to fall in.

What many tooth designers failed to appreciate is the virtue of "subocclusal" areas—surfaces which face opposing surfaces, but which do not actually come into occlusal contact. The proper use of subocclusal areas solves the difficulty. By the neat trick of making part of the morsel surface nonoccluding (subocclusal), it becomes possible to design teeth with full buccolingual breadth, while, at the same time, presenting restricted working occlusal surfaces for reduced resistance.

Fig. 1.



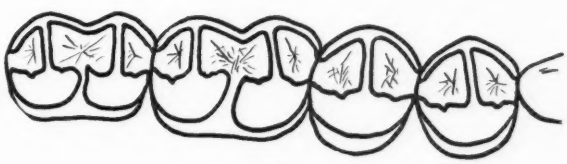


Fig. 2.

Fig. 1.—Lower right four posterior teeth in typical arrangement without the reduction of cutting margins.

Fig. 2.—Upper right four posterior teeth in typical arrangement without the reduction of cutting margins.

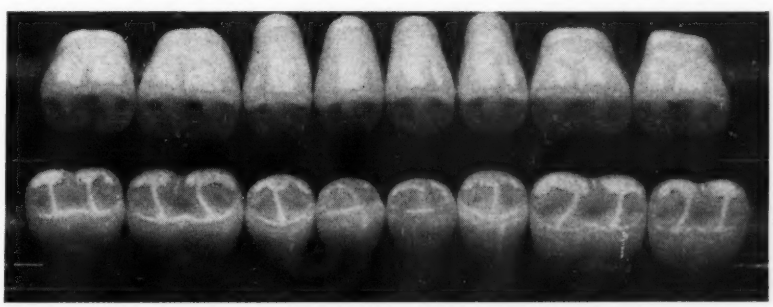


Fig. 3.—A carded set of sixteen posterior teeth incorporating the features described. In this set, the upper teeth are of porcelain and the lower teeth are of plastic.

Theoretically, we could make a tooth in two sections: a buccal veneer and a lingual table. We would arrange the buccal section to meet the esthetic requirements and to make proper contact with the cheek, then independently arrange the

lingual section to stabilize the denture and to make proper contact with the tongue. Practically, however, we meet the problem without actually dividing the tooth in this way.

We have so designed the teeth that their crushing surfaces can be set to the lingual side of the dental ridge while their cutting surfaces lie buccally, thus centralizing the load, and, at the same time, reducing the resistance.

INCLINED PLANE ACTION

There is also the important problem of directing the closing force on the supporting structures so that the denture bases will not slide along the ridges. This is a simple problem of statics.

The first law of statics is that force be directed at right angle to the support. Table tops are therefore horizontal. This places the supporting surfaces at right angle to the pull of gravity so that objects will not roll or slide off the table.

This same law of force at right angle to support operates with a denture base. Closing force is directed on the residual ridge according to the inclination of the tooth surface receiving the force. So we select teeth whose occlusal surfaces can be placed parallel with the dental ridge.

TOOTH ARRANGEMENT

Dentures must be made for mouths in which, unfortunately, the upper and lower dental ridges are not parallel. Obviously, it is impossible to place both upper and lower teeth parallel with both upper and lower ridges in such cases. It then becomes a question of whether to make the occlusal surfaces parallel with the upper or the lower ridge, or to split the difference. The logical course under this circumstance is to favor the weaker ridge—usually the lower one. For the sake of simplicity, we shall describe the arranging of the teeth for stability of the lower denture, remembering that, at times, it is the upper one that needs to be favored.

Now, since lower ridges are not entirely straight, the occlusal scheme, to be parallel with a curved lower ridge, must be curved also.

In nature, we recognize the "curve of Spee," and, in prosthesis, we have the "compensating curve." More important for the success of dentures is the "stabilizing curve." These three curves look similar and may seem to be identical, but they are based on different concepts.

The stabilizing curve disregards the pronouncement of von Spee and the advocacy of a compensating curve for producing protrusive balance. To be guided in denture construction by either the curve of Spee or the compensating curve would be a mistake in engineering. We can produce protrusive balance without any curve whatever in the working occlusal surfaces of the teeth, and we should do so where there is no curvature of the ridge. It usually happens, however, that the placing of the occlusal surfaces of the teeth parallel with the underlying ridge results in a curve that is useful in protrusive balance. So, from the practical standpoint, it makes little difference, in the average case, whether we aim for any special kind of curve. However, not all cases are average and, with the unusual case, it may be highly important to arrange the teeth to what becomes a stabilizing curve. This is

right from the standpoint of statics, even though it may differ from a curve of Spee or a compensating curve.

So it might be said that we should use special forms of posterior teeth in special positions according to engineering principles, instead of natural forms in anatomic positions. The reasons for the special forms and placement will become more evident as we proceed with the arrangement of the teeth.

Special forms and the correct placement of artificial posterior teeth meet, to great degree, the requirements of stability, comfort, chewing efficiency, conservation of supporting structures, appearance, and ease of obtaining the required arrangement. But one important requirement—materials of which the teeth are made—should be discussed briefly before we proceed further with tooth arrangement.

TOOTH MATERIALS

The two most suitable materials at our disposal are porcelain and plastic. It should be emphasized that there is considerable difference in the abrasiveness of different kinds of porcelain, especially if the porcelain teeth are ground. Recent techniques of firing have produced porcelains that are dense and only slightly abrasive if they are repolished after being ground. As for plastic teeth, the methylmethacrylate wore away too rapidly even in the average mouth. The cross-linked copolymer plastic teeth resist abrasion better than the methylmethacrylate ones and can be worn satisfactorily by most patients. But even the new cross-linked plastic teeth when opposed to teeth of the same material sometimes suffer a greater loss through wear than is desirable.

Most patients dislike the feeling of porcelain-to-porcelain as well as the "crockery" sound when the teeth strike together. Plastic teeth are less open to these objections.

Still more recently, it has been demonstrated[9] that certain advantages, including decreased wear, are possible by occluding dense smooth porcelain teeth against cross-linked plastic ones. The degree of wear can be still further reduced by the design of the teeth themselves. With porcelain-to-plastic teeth of appropriate design, the degree of wear is excellent in the average mouth. The clashing sound is muted, and abrasion is so reduced that it is no longer a disadvantage.

After four years of testing, it seems adequately proved that the occluding of dense, smooth porcelain teeth to tough, cross-linked copolymer plastic ones offers improvements, such as more efficient mastication with all types of food and with unimpaired efficiency through years of use. Also, it is found that the porcelain teeth are less liable to fracture than if they are opposed by other porcelain teeth. While dentures may be made, for example, with all of the upper teeth of porcelain, and all of the lower ones of plastic, I prefer to use only the upper posterior teeth of porcelain, in most cases, while all of the other teeth, both anterior and posterior, are of plastic.

It is wise to explain to the patient something of the problems of tooth abrasion, pointing out that, although too much wear is undesirable, properly controlled wear tends to protect the residual ridges, and may also protect the joints where the lower jaw hinges. Fortunately, we have a good measure of control over this factor of wear.

SMOOTH GLIDING

The arrangement of the teeth on the articulator should be such that in the patient's mouth the teeth will glide smoothly from centric to eccentric positions without any interference. Also, there should be no premature contacts on the incisors in protrusion, nor premature contacts on the working side in the lateral positions. At the same time, we should try to prevent, so far as possible, the necessity for grinding the occlusal surfaces. Especially do we wish to avoid removing the glaze from the porcelain molars where they oppose plastic teeth. Where grinding of the porcelain occlusal surfaces is done, these surfaces should be repolished.

SECURING CENTRIC RELATION

With these general considerations regarding posterior teeth in mind, let us next consider the patient's jaw relation and its transfer to the dental articulator.

It seems that some form of tracing device is almost necessary in finding and fixing centric jaw relation, if we hope to arrange the posterior teeth with the required accuracy. While it is true that some patients tend to do much of their chewing in more or less protrusion, this is not sufficient reason for arranging the teeth in centric occlusion to some eccentric jaw relation. Where a patient favors some eccentric relation, this fact may be of importance if intercusping teeth are used, but with the recommended teeth we can contrive the occlusal scheme so that there is balanced occlusion in centric as well as in eccentric jaw relations. This removes the question of whether to arrange the teeth to centric *or* to some eccentric relation. We do both. We mount the lower cast to the upper one at *centric* jaw relation and then make certain articulator adjustments in anticipation of expected changes in the patient's jaw relations.

CHANGING JAW RELATIONS

Unfortunately, the jaw relations found at the time of denture construction are not always permanent. Jaw relations start to change as soon as the dentures are put to use. Because of these changes in jaw relation, the maintaining of balanced occlusions over any long period of use will require frequent adjustments unless we foresee and forestall this necessity.

Dentures which are balanced at the time of installing them usually soon make premature contact on the incisors in protrusion and on the buccal surfaces of the upper teeth of the working side in lateral position. For this reason, we should make suitable articulator adjustments differing from those derived ordinarily from the wax interocclusal records.

ARTICULATOR ADJUSTMENTS

The most satisfactory results are obtained by the use of an adjustable articulator and individual eccentric mouth records, although fairly acceptable results are possible without such records and without an adjustable articulator.

When no eccentric jaw records are made, and only average settings are used, the downward and forward condyle reading should ordinarily be 45 degrees when the occlusal plane is parallel with the bench top. This is about 10 degrees steeper than the generally accepted average reading. The steeper condylar path can be

established, even on an articulator with fixed settings, by mounting the casts so that their posterior ends are depressed. This brings the occlusal plane to an increased angle with the condylar paths.

The more meticulous dentist will, however, use an articulator with individually adjustable condylar paths, and will set these paths by means of eccentric records made in the patient's mouth.

Theoretically, we should adjust the articulator to three separate records: right lateral, left lateral, and protrusive. Practically, however, only the protrusive record need be used. The condylar adjustments made from the protrusive record will serve for all eccentric relations. This is because the difference, where any exists, between the setting of a path for protrusive and for lateral movement is slight—much less than the difference between the original setting from the mouth record and the path resulting from changes which develop while the dentures are being worn. Whatever the condylar readings derived from the protrusive record, these readings should be increased 10 degrees or more.[10]

As for *when* to increase the steepness of the condylar guides, this can be done before or after the wax trial dentures have been tested in the patient's mouth. The advantage of doing it before is that it does not become necessary to change the positions of the teeth after they have been arranged once. The disadvantage is that if the teeth are arranged on the articulator to increased condylar steepness, they cannot be so easily tested for eccentric occlusions in the patient's mouth.

If, however, the steepness of the condylar guides has been learned by means of the protrusive record, there is little point in testing the eccentric occlusions in the patient's mouth. For this reason, most dentists prefer to increase the steepness of the condylar guides before setting the teeth, thereby avoiding the necessity for realigning the teeth after the try-in. It is necessary, then, only to test the dentures in the patient's mouth for phonetics, esthetics, and occlusion in centric relation.

Increasing the steepness of the condylar guides, as just suggested, guards against damage to the supporting structures due to changing *eccentric* jaw relations. There is, however, also danger from a changing *centric* relation to be guarded against. The way to meet this hazard is to lengthen the posts of the articulator after the dentures have been tested in the patient's mouth, and before they are invested in the flasks. This lengthening of the posts will be discussed at the end of the tooth-arranging technique.

Assuming that the steepness of the condylar guides has been increased, but that the posts have not yet been lengthened, the articulator is in adjustment for arranging the posterior teeth.

Since our present interest is in posterior teeth, we shall not discuss the arrangement of the anterior teeth except to point out that, with the special posterior forms here advocated, it is not necessary to make any changes in the anterior teeth to accommodate the setting of the posterior ones.

So we assume that the casts are mounted, that the degree of jaw separation is fixed by the incisal pin of the articulator, that the condylar readings have been increased, and that the anterior teeth have been fixed firmly in their positions. We are now ready to select and arrange the posterior teeth.

SIZES OF THE POSTERIOR TEETH

We first determine the appropriate sizes of the teeth for the four quadrants: lower right, lower left, upper right, and upper left. Ordinarily, the 1 by 16 combination as furnished by the manufacturer is acceptable, but in asymmetrical cases, it is best to select mesiodistal sizes independently for the four quadrants. In this calculation, we disregard the lower second molar. We want the combined mesiodistal lengths of the two bicuspids and first molar to equal the distance between the distal side of the cuspid and the place where the lower ridge starts its more abrupt upward inclination.

In some mouths, the horizontal part of the residual ridge extends further back on one side than on the other, in which circumstance the combined mesiodistal lengths of the two bicuspids and first molar should be greater on that side. For the dentist who does not carry his own stock of teeth, it will sometimes be necessary for him to order from more than one set of 2 by 8 according to the size requirements of the four quadrants.

In a mouth whose ridges present decided front-to-back curves as seen from the side, the above measurements cannot be used. In this case, the first molar will necessarily have to overlie a sloping surface. The lower first molar should extend back as far on the ridge as the following requirements permit: (1) there should remain sufficient space for the lower second molar, (2) the first molar should not lie over an area where the upward sweep of the ridge is excessive, and (3) the first molar should lie over firm ridge structure so that the ridge will not yield too much under chewing action.

We make a pencil mark on the lower cast to indicate the place over which the distal end of the lower first molar should lie and select the tooth size accordingly. With the articulator closed, we make another pencil mark on the upper cast just above the lower mark. This indicates the place where the distal edge of the upper first molar should lie. We measure from the distal side of the upper cuspid to this upper mark to find the appropriate combined mesiodistal lengths of the upper bicuspids and first molar and select the size of teeth accordingly.

SETTING THE LOWER TEETH

It makes little difference whether we set the upper or the lower teeth first, so long as their positions conform to the principles involved. But since it is the lower denture that is in greater danger of dislodgment, we first place the lower teeth to assure greater stability of the lower denture.

It is convenient to use two kinds of wax. The kind for attaching the teeth to the baseplate should be somewhat sticky to hold the teeth and of such plasticity that slight warming will permit us to move any tooth slightly after the adjacent teeth have been placed. The other kind of wax is for completing the contours and for holding the teeth in their positions. This second wax should be more brittle and less sticky. The brittleness prevents any inadvertent movement of the teeth after they have been arranged, and the lack of stickiness facilitates the removal of excess wax from the teeth. Let us designate the two kinds of wax as "softer" and "harder."

Before starting to set the posterior teeth, we increase the occlusal vertical dimension by one millimeter measured at the incisal pin and lock the incisal pin at this increased opening until all of the teeth have been arranged.

We start by setting the lower first bicuspid of one side. With a hot spatula, we seal a small quantity of softer wax to the trial base and place the lower first bicuspid in proximal contact with the cuspid. The ideal mechanical placement is directly over the center of the residual ridge. Occasionally, however, this would bring the first bicuspid too far lingually to appear pleasing, in which circumstance, we can allow this tooth to stand somewhat buccally to its ideal mechanical position.

We next seal some softer wax where the second bicuspid and first molar are to be placed and line up these teeth behind the first bicuspid. The center of the second bicuspid can nearly always be centered with the dental ridge, and the first molar offers even fewer exceptions. The second bicuspid and the first molar are the teeth on which we wish to concentrate the closing force, so their positions are of prime importance to denture stability.

Before the wax has time to become hard, we perfect the alignment of the three teeth just set.

As already pointed out, the center of each tooth should lie over the center of the residual ridge. With the newly developed teeth, this brings the crushing areas just to the lingual side of the ridge. As seen from the side, the occlusal surface of each tooth should lie parallel with the underlying ridge. If the ridge is practically straight in that part underlying these teeth, there will be no curvature of the occlusal scheme; if the ridge curves, the occlusal alignment will curve to parallel the ridge.

The height of the occlusal surfaces should ordinarily be halfway between upper and lower ridges. However, when one ridge is resorbed much more than the other, the occlusal surface should be farther from the ridge that is more resorbed. This is for the purpose of establishing the vertical height of the occlusal plane, and is independent of the placement of the occlusal surfaces for stabilizing the dentures.

To summarize: From the occlusal view, the buccolingual center of each tooth should lie over the center of the ridge. From the buccal view, each lingual table should lie parallel with that portion of the ridge immediately below. From the mesial view, each lingual table should lie on the horizontal plane.

While the general rule is to align the lingual tables horizontally, sometimes we should tilt them slightly to favor one denture or the other. The lower denture can be made more stable by facing the occlusal tables somewhat buccally. This directs the closing force more nearly toward the center of the lower foundation. Of course, the "equal and opposite force," according to Newton's third law, directs the force more to the outside of the upper foundation and thereby tends to make the upper denture less stable. This buccolingual tilting does not interfere with lateral balance when using the teeth and technique here advocated.

Next, we arrange the two lower bicuspids and first molar similarly on the opposite side of the mouth. At this point in the procedure, there is some danger of setting the teeth of one side of the mouth higher than on the other, unless the distance from the ridge to the occlusal table is measured. A pair of calipers or a millimeter gauge can be used to measure the distance from the ridge to the

occlusal surface. When both right and left lower bicuspids and first molars are arranged, the upper teeth are set.

SETTING THE UPPER TEETH

The same principles apply in arranging the upper teeth as with the lower ones. We seal a small mass of softer wax to the upper trial base and place the upper first bicuspid in proximal contact with the upper cuspid. By setting the tooth a little long in the softened wax, we can close the articulator to push it to its proper vertical height. With finger pressure, we then push it to its proper horizontal position, aligning it in pleasing relation to the cuspid. With the special occlusal forms, there is considerable latitude in the horizontal placement of all of the posterior teeth.

As we set the upper second bicuspid and first molar, we remember that these are the teeth designed to receive most of the load. For this reason, their correct placement is especially important. The upper occlusal tables should lie just to the lingual side of the center of the upper ridge to produce favorable leverage in the upper denture. This usually offers no difficulty. In some cases, however, the upper ridge lies too far inside the lower one, even when the teeth are set to a "cross-bite." In such cases, it becomes necessary to set the upper teeth so that their lingual tables lie buccal to their ideal positions.

We set the upper second bicuspid and first molar of one side behind the first bicuspid for good appearance and with the occlusal tables as nearly as possible just lingual to the upper ridge. If the upper buccal surfaces come end-to-end with the lower ones or even lingual to them in a cross-bite arrangement, the mechanical gain usually more than offsets any esthetic loss. Occasionally, we set the bicuspids to the usual buccal overlap and the molars in the cross-bite position.

Whatever the horizontal relation of the upper teeth to the lower ones, we test the teeth in right lateral position while the wax is still plastic. We glide the lower teeth to the right side, testing to make sure that the upper and lower occlusal surfaces maintain contact from centric to right lateral position. It is not necessary to test the left lateral or the protrusive glide unless the stabilizing curve is steep.

We are concerned now with the place where the distal edge of the upper first molar lies with respect to the distal edge of the lower first molar. Since the horizontal overlap of the incisors will differ in different mouths, the mesiodistal relation of the opposing first molars varies from case to case, unless the upper and lower sets of teeth have been selected with the view to making the distal edges of the first molars coincide. Without this special precaution and with a large horizontal overlap of the incisors, the lower molars may lie distal to the corresponding upper ones; with an end-to-end arrangement of the incisors, the lower molars may lie too far to the front. We should have selected upper teeth of a size calculated to make the distal edges of upper and lower molars coincide more or less closely. Even so, it is sometimes necessary to alter the mesiodistal lengths of these teeth by grinding.

It is important to line up the distal edges of the first molars when it becomes advisable to omit the upper second molars entirely, because, in this situation, both

protrusive and lateral balance begin at this line. The exact coincidence is less important when the upper second molars are used.

Next, we arrange the two bicuspids and first molar of the opposite side similarly.

We increased the occlusal vertical dimension one millimeter before starting to arrange the posterior teeth. We now reset the incisal pin to reduce the vertical dimension to the original position. This affords the opportunity to refine the occlusions by pressing the articulator together in right and left lateral positions until the pin again touches its stop.

We next complete the labial, buccal, and lingual contours with harder wax and allow the wax to cool.

SETTING THE SECOND MOLARS

All of the posterior teeth have now been set except the second molars. The incisal pin should be disengaged so that the teeth already set will maintain the jaw separation. It is at this point that we make the decision as to whether or not to use the upper second molars. There are three situations in which it is advisable to omit these teeth: (1) when the tissues underlying the lower second molars are so yielding that chewing pressure upon them would depress the posterior ends of the lower denture, causing the lever action to lift the anterior end, (2) when the forwardly tilted lower second molars leave insufficient space for the opposing upper second molars, and (3) when the backward facing of the upper second molar would be so great as to cause too great a forward thrust on the upper denture. Fortunately, these three situations are rather exceptional, but when any one exists, it is important to know how to proceed. And, so at this juncture, we shall discuss the means of producing protrusive and lateral balance, first without and then with the upper second molars.

BALANCE WITHOUT THE UPPER SECOND MOLARS

It is by tipping the lower second molars toward the front of the mouth that we achieve protrusive balance, and by tilting them lingually that we achieve lateral balance. We first attach small masses of softer wax to the lower trial base and set the lower second molars with their mesial edges against the distal edges of the lower first molars, tilting the lower second molars up at the back so that when the lower anterior teeth are carried to the incisive position, the lingual tables of right and left lower second molars will glide on the distal edges of the right and left upper first molars. The vertical overlap of the incisors will govern the tilt of the lower balancing teeth; the greater this overlap, the greater will need to be the tilt of the lower second molars.

We have just fixed the degree of forward inclination of the lower second molars to produce balance in protrusion. Now without changing this forward inclination, we tilt these teeth lingually to the extent necessary to maintain occlusal contact as the lower teeth are carried to right and left lateral positions.

In manipulating the lower second molars for balance, there will sometimes be interference at the distobuccal corners of the upper first molars. This difficulty is easily overcome by grinding off these corners, or the mesiobuccal corners of the

lower second molars, or a little of both. With this grinding, the lower second molars can be set at any inclination needed for protrusive balance. This balance is maintained as the lower second molars glide upon the distal edges of the upper first molars.

When the upper second molars are omitted, the lower second molars should be lined up more nearly with the upper first than with the lower first molars. This brings the lower second molars further buccally, causing the lingual table to function better, and providing more space for the tongue. The buccal halves of the lower second molars, being nonfunctional, can be narrowed or beveled to any desired extent.

Treated elsewhere,[2] there is a somewhat more intricate method of handling the lower second molars, but the method just described produces acceptable results.

BALANCE WITH THE UPPER SECOND MOLARS

When the upper second molars are used, we manipulate all four second molars to produce protrusive and lateral balance. The lower second molars are tilted toward the front for protrusive, and toward the center of the mouth for lateral balance, as already suggested; then, the upper second molars are laid on them and waxed to position.

All of the teeth are now arranged and ready for testing the occlusions of the articulator. With the incisal pin still released, we move the lower teeth forward to the position of incision to test the protrusive balance, and into right and left lateral positions to test for lateral balance, making refinements of the inclinations of the second molars, if necessary.

Next we complete all of the contours in harder wax, after which the trial dentures are ready for testing in the patient's mouth.

TESTING THE WAX TRIAL DENTURES

At the try-in stage, we test phonetics, esthetics, and centric occlusion. If we have increased the steepness of the condylar guides as advocated, the eccentric occlusions will not be in balance in the patient's mouth—and should not be. The molars should make premature contact in protrusion so that the opposing incisors fail to meet, and the teeth of the balancing side should make premature contact in the lateral positions.

After dismissing the patient, we return the wax trial dentures to the articulator for the final articulator and occlusal adjustment before investing them.

SHIFTING THE LOAD

At this point, we shift the occlusal load to the molar regions in order to protect the dental ridges and the temporomandibular joints. Some dentists still fail to observe the detrimental changes that occur while ordinarily constructed dentures are worn. Failure to appreciate the extent of the damage is due partly to the fact that our patients usually tolerate discomfort to an extent that they are not driven to the dental office for relief. Fortunately, this damage can be prevented to great extent by maintaining the occlusal load in the molar regions.

OCCLUSAL PIVOTS

In spite of the fact that the evils of excessive pressure in the anterior part of the mouth have been with us all along, it was not until recently that we realized their serious importance and appreciated the value of occlusal pivots in preventing and correcting these evils.[9,10] Except for the bending of the mandible and softening of the dental ridges, the evil effects of this excessive pressure can be corrected more or less by pivoting the mandible in the molar regions. Our interest in the matter at this point is that the dentist who wishes to make use of occlusal pivots can do so at this place in the procedure. The principle is easily applied by lengthening the posts of the articulator after the wax trial dentures have been tested in the patient's mouth and before they are invested in the flasks.

First, we lock the incisal pin in contact against its stop, with the teeth in centric occlusion. Then we raise the posts 1 mm. or more according to how much descent of the condyles we anticipate. This, of course, causes a separation of the posterior teeth on the articulator. To close this gap, we place two small masses of soft wax in the lower trial base under the right and left second molars, replace the lower trial base on its cast, and force the articulator closed until the incisal pin again makes contact with its stop.

This adjustment raises the lower posterior teeth and brings them again into correct position for balanced occlusions on the articulator. We then make a final check of the occlusions before sealing the wax trial dentures to their casts ready for investing in the flasks.

PRESERVING CENTRIC RELATION

It is important to preserve the recorded centric relation during all of the steps right up to the time of installing the dentures. The best way so far devised is to key and lubricate the bases of the casts so that they can be removed from their mountings for the curing of the denture bases, and be replaced exactly on these mountings for refinements of the occlusions before removing the casts from the cured dentures.

CONVERTING THE WAX TRIAL DENTURES INTO CURED DENTURES

We pry the casts with the attached wax dentures from their mountings and set the articulator aside for the subsequent reception of the cured dentures.

Before investing the dentures, we lubricate the bases of the casts with talcum or some other suitable separating medium so that they can be retrieved subsequently and cleansed for accurate remounting on the articulator.

Converting the wax trial dentures into cured dentures is then done in the usual way.

REFINING THE OCCLUSIONS

After the cured dentures are deflasked, and before the casts are removed from them, we seat the casts again on to their mounting plasters on the articulator and make any necessary occlusal refinements according to the articulator adjustments previously made.

We leave the incisal pin disengaged in order to check the occlusions and make any necessary refinements. With a sheet of thin carbon paper between opposing

occlusal surfaces, we tap the teeth together to discover any spots of premature contact. We do this first in centric and then in the eccentric positions, reducing high spots, if necessary.

With porcelain teeth occluding against plastic teeth, it is of considerable advantage to preserve the original firing glaze on the porcelain. For this reason, we attempt to avoid any grinding on the porcelain molars.

When the carbon paper tests show no places of premature contact, we make further refinements by interposing abrasive paste and moving the articulator into the eccentric positions that the patient will make. This assures a smooth gliding in the patient's mouth.

Since we aim to preserve the original glaze on the porcelain molars, we should use an abrasive paste that will cut plastic but not porcelain.

After the smooth glide has been produced, we wash the abrasive from the teeth, and test the occlusions again with thin carbon paper. We look for areas of excessive contact, especially on the cuspids, and reduce any areas thus disclosed.

Fig. 4.

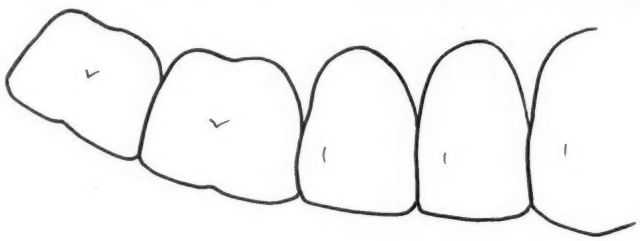


Fig. 5.

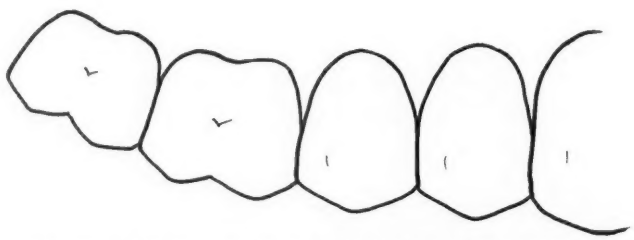


Fig. 4.—Another view of the same teeth as in Fig. 2. In many instances, the buccolingual edges of the posterior teeth present too straight a line to appear pleasing, especially in younger patients. The difficulty is easily overcome as shown in Fig. 5.

Fig. 5.—The same as Fig. 4 after some of the buccal cutting margins have been reduced. Aside from improving the appearance, this reduction further centralizes the occlusion. Slicing the mesial and distal sides as shown here creates the illusion of projecting cusps such as are observed in unworn teeth.

ESTHETIC REFINEMENTS

At this stage, the posterior teeth may present too straight a line along their bucco-occlusal edges for the best esthetic effect. Alteration is easily made at this time while the dentures are still mounted on the articulator. The teeth may be given the illusion of carrying projecting cusps by the simple process of slicing the mesial and distal edges at an angle, leaving points to represent buccal cusps. This grinding to give the appearance of cusps may be done to a slight or great extent, or it may be done to a slight extent at this time, with the possibility of further modification after the dentures have been installed (Figs. 4 and 5).

Not only does this grinding generally improve the appearance of the dentures, but at the same time it increases the sluicing of the occlusal areas and thereby further reduces the force necessary to pass through the food. It also tends to centralize further the occlusal load, and thereby enhances the stability of the dentures. After the grinding has been completed, the ground surfaces of any porcelain teeth should be polished to restore the gloss.

Next we remove the casts from the bases and make the dentures ready for delivery.

DELIVERING THE DENTURES

We insert the dentures and ask the patient to maintain a light closing pressure until the bases become seated. At this stage, the molars will strike prematurely if we have employed them as pivots. We call the patient's attention to the fact that the front teeth do not quite meet and assure him that the gap will begin to close almost immediately. The patient is dismissed.

SUBSEQUENT INSPECTION

It will be necessary to see the patient again for inspection of the tissues and the occlusions. After the dentures have been worn for two days, they will be in balance, or nearly so, in centric and eccentric positions if we have correctly anticipated the changes in the temporomandibular joints and the denture-supporting structures. If balance is attained in two to four days, the patient can be dismissed. However, if there has not been sufficient change to bring the teeth into balance, we make slight reductions on the lower molars. A reduction of ½ mm. on the molars will cause about 1 mm. closure at the incisors, so we should use caution not to reduce the molars so much as to throw the load to the front of the mouth.

Although the patient is dismissed as soon as the occlusions are satisfactory, and although the teeth have been designed to prevent, so far as possible, the gradual overloading of the anterior part of the mouth, the occlusions should be checked, perhaps annually. Even though dentures constructed according to the procedure here advocated are decidedly more conservative of the temporomandibular joints and the dental ridges and will remain in adjustment longer than those made by older methods, it is still possible for the teeth to get out of adjustment. Continued periodic inspections should be part of our denture service.

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FINDING LOST PROSTHODONTIC DIMENSIONS

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FINDING THE CORRECT PLANE of occlusion and the correct height of the interridge crestline space when disease has destroyed the normal conditions is one of the most pressing problems of prosthodontics.

It is the purpose of this article to indicate the character of evidence with which we must deal when considering it. It is a problem that involves the culmination of slow metamorphoses of alveolar bone from the sixth year of life to old age. During the sixth year, the normal height of the interridge crestline space is established by the eruption of the mandibular and maxillary first molars (Fig. 1). The elevation of the plane of occlusion is established at the same time and completed during the eighteenth year of life.

The heights of the interridge crestline spaces vary normally from patient to patient and no average height can be struck.

Disease processes *increase* the heights of the interridge crestline space because of atrophic changes in highly specialized alveolar bone and cause the ridgecrests to recede in opposite directions from the plane of occlusion. Inversely, the plane of occlusion, because of disease processes, is approached from opposite directions by the mandibular and maxillary ridgecrests thereby *decreasing* the height or vertical dimension of the interridge crestline space. Increases in the heights of the spaces are discernible in roentgenograms (Figs. 2 and 3) and on casts (Fig. 4) of the mouth.

Roentgenograms do not lend themselves readily to the establishment of interridge crestline dimensions. Their accurate recapture depends exclusively on pre-extraction or "control" casts of the mandible and maxillae.

The elevation of the plane of occlusion, and the vertical dimension of the interridge crestline space can be recaptured from control casts in millimeters, symbols that are understandable.

The incisive papilla anterior to the rugae will be used as a point of beginning from which to gauge all extant deviations from the normal plane of occlusion and the normal interridge crestline space, or the equivocally, so-called, "height of the bite." The extant elevation of the plane of occlusion will be gauged from the incisive papilla to the incisal edge of the maxillary central incisor.

The vertical dimension of the interridge crestline space will be gauged as a separate entity from the incisive papilla to the ridgecrest of the mandible in the median line.

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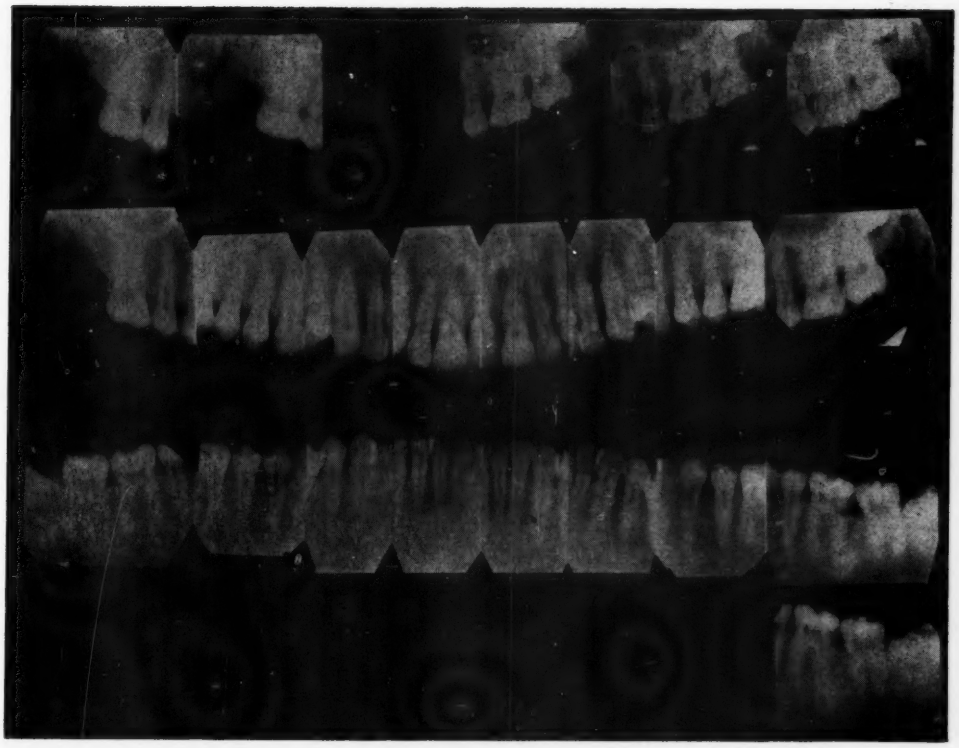

Fig. 1.—A roentgenologic study of normal alveolar bone showing the height of the alveolar ridgecrest and its relation to tooth crevices for comparison with Figs. 2 and 3.

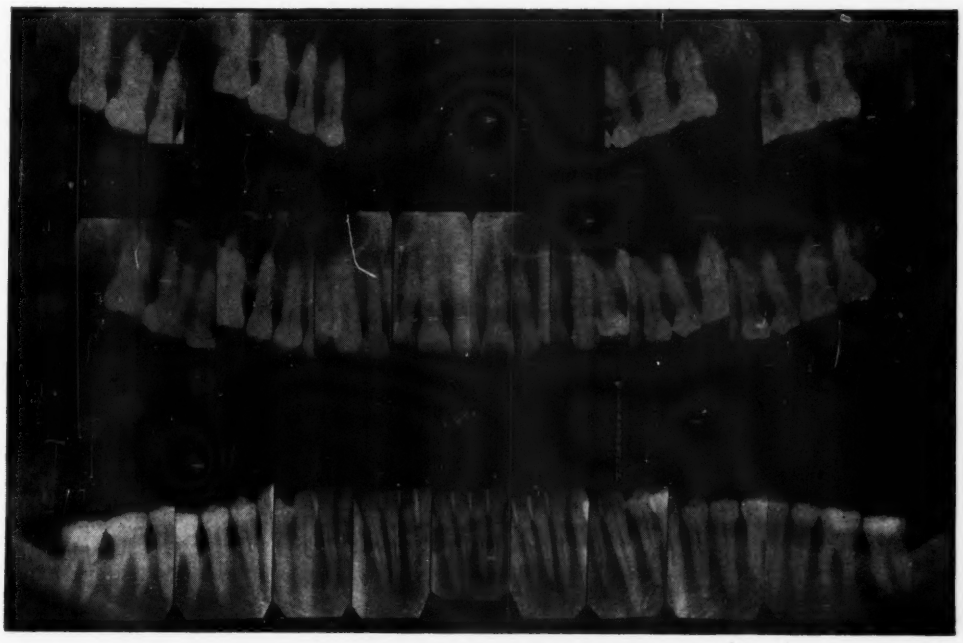

Fig. 2.—Disease is beginning to destroy normal alveolar bone. Atrophic changes will progress in opposite directions from the plane of occlusion. This deviation from the norm must be described as the extant height of the interridge crestline space.

Fig. 3.—Disease has destroyed the alveolar bone in both processes. The absorption of the alveolar bone in both processes continues in opposite directions from the plane of occlusion, thus increasing the height of the interridge crestline space, or "height of the bite."

Fig. 4.—Casts of maxillary dentures in occlusion with natural mandibular teeth clearly depict *increases* in the height of the interridge crestline space while teeth are present. The numbers on the casts indicate the elevations of the planes of occlusion and the vertical dimensions of the interridge crestline space heights.

Fig. 4 shows casts of mandibular natural teeth with casts of maxillary dentures. The numbers on the casts signify in millimeters the elevations of the planes of occlusion and the heights of the interridge crestline spaces.

The elevation of the plane of occlusion was gauged from the fossa formed within the baseplate of the denture by the incisive papilla, from thence to the incisal edge of the maxillary central incisor, and recorded on the cast in millimeters. The vertical dimension of the interridge crestline space was taken from the fossa to the median line of the mandibular ridgecrest and also recorded in millimeters on the cast for later elaboration. The mandibular casts (Fig. 4) show evidence of atrophic changes and *increases* in the heights of the interridge crestline spaces.

The casts in Fig. 5 reveal exciting causes of *decreases* in the heights of interridge crestline spaces.

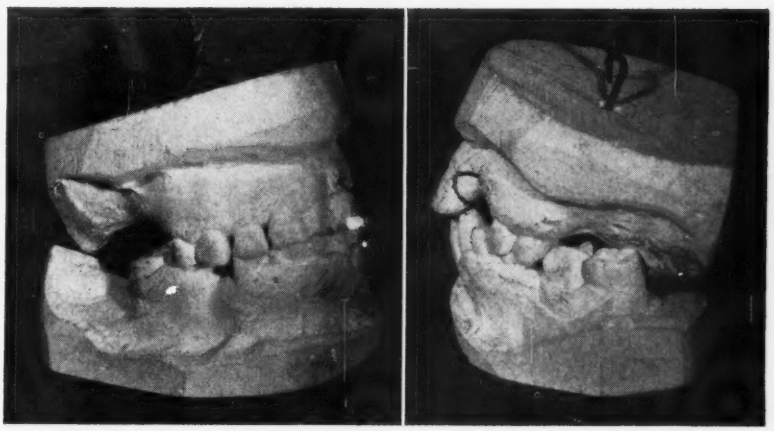

Fig. 5.—Casts showing the ridgecrests progressing toward the plane of occlusion from opposite directions to *decrease* the height of the interridge crestline space; a dimension (extant) to be recaptured from control casts at the chair, when registering centric occlusion following the surgical preparation of the ridges.

DISEASE FACTORS THAT DECREASE THE HEIGHT OF THE INTERRIDGE CRESTLINE SPACE

Factors that decrease the heights of interridge crestline spaces have their inception with (1) staggered extractions, (2) hypertrophied maxillary tuberosities, (3) abraded teeth, (4) drifting teeth, and (5) exfoliating teeth. Any or all of these may occur in casts of the same mouth, as in Fig. 5. This patient was 72 years of age.

The patient whose casts are shown in Fig. 6 was 33 years of age, and he refused to have the six maxillary anterior teeth removed. The height of the interridge crestline space was 8 mm. The case was treated surgically and restored uneventfully with removable partial dentures. The casts show conditions before and after surgical intervention.

There are at least thirty malacic diseases of bone conducive to atrophic changes in the heights of interridge crestline spaces. Atrophy is the culminating factor in all of them.

Human errors at the chair also increase the height of the interridge crestline space.

Nothing in the realm of faulty prosthodontic techniques can epitomize more concisely the ill effects of technical errors at the chair when re-establishing centric occlusion than the mismanagement of relining dentures.

Fig. 6.—Casts of the mouth before and after surgical intervention for the preparation of the maxillary ridge for a denture.

The review of a present-day relining technique compared with control casts (Fig. 7) will indicate a discrepancy and some deleterious effects resulting from inadvertent increases in the correct height of the interridge crestline space.

The technical procedure involved the making of impressions and casts of both jaws. The casts were mounted on the articulator in occlusion, with the pin set to conserve the extant height of the interridge crestline space. The plaster teeth were removed, and the ridges were prepared in simulation of the surgical preparation of the ridge for the reception of the denture, which, when finished without trial, was returned to the mouth. When edema had subsided, the denture lost its intimate fit. Having fulfilled its purpose as an immediate restoration, its transitory status was converted to one of permanency.

Unfortunately, relining had increased the height of the interridge crestline space 3.5 mm. above the extant limit of 12.5 mm. to a height of 16 mm. The increased height induced an acute temporomandibular arthrosis. This is a common occurrence following the omission of control casts, or similar safeguards when centric occlusion is being established at the chair.

CLASSIFICATION OF DENTURE PATIENTS

Denture patients will be described under four separate categories: (1) patients about to lose their maxillary teeth only, (2) patients about to become completely edentulous, (3) completely edentulous patients requiring the renewal of old dentures or new dentures, and (4) completely edentulous patients without dentures, records, pre-extraction casts, or any record of the height of the interridge crestline space (Fig. 8).

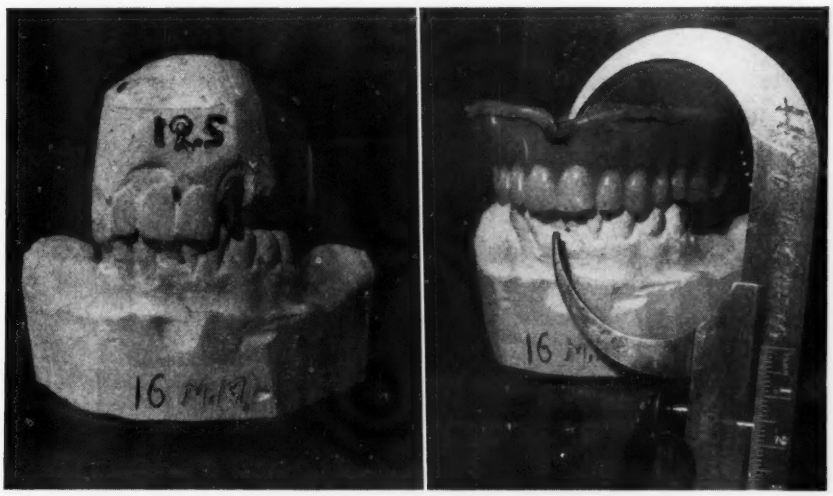

Fig. 7.—Casts showing a 3.5 mm. increase (from 12.5 to 16 mm.) in the height of the interridge crestline space as a result of an indiscriminate relining technique.

MAXILLARY COMPLETE DENTURES

In this category, complete denture control casts are mandatory. They should reveal details of the incisive papilla and the crevices of the maxillary and mandibular incisor teeth. The incisive papilla and the mandibular ridgecrest in the median line are in plain view (Fig. 9). The intervening space between the incisive papilla and the mandibular ridgecrest in its median line is spanned with inside calipers, and its dimension is recorded on the cast in millimeters.

The maxillary occlusion rim is contoured to the face and lips and heated. The patient closes into it to the corresponding millimeter mark on the caliper, which had been recorded on the casts (Fig. 10).

When gauged with reasonable accuracy, the plane of occlusion and the interocclusal distance or so-called "freeway space" are automatically restored.

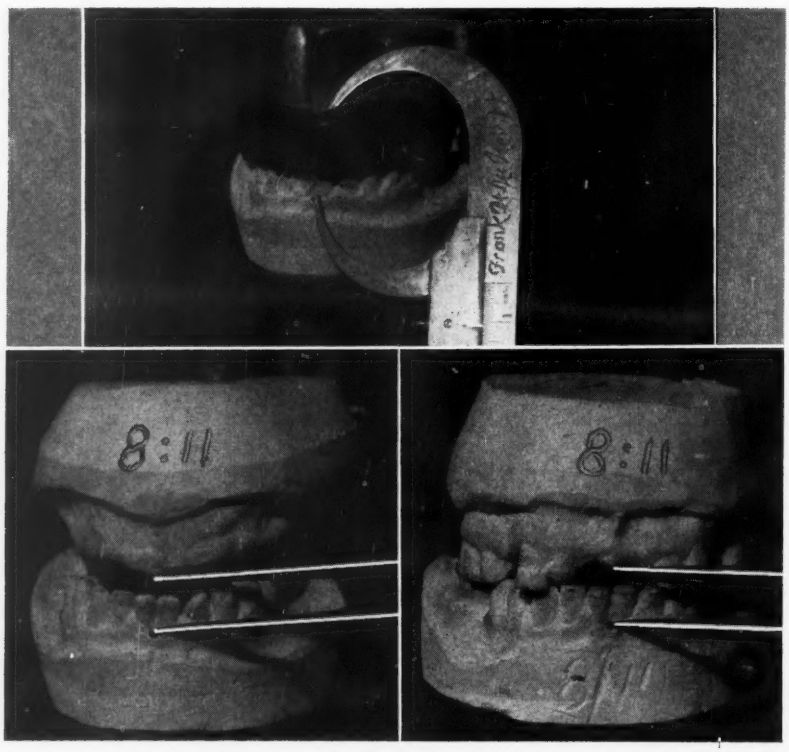

Fig. 8.—A complete denture case in the first category, showing the method of recapturing the interridge crestline dimension from control casts.

Fig. 9.—Casts with the maxillary incisor teeth removed from the maxillary cast to *expose* the incisive papilla for the purpose of *gauging* the vertical dimension of the interridge crestline space.

DENTURES FOR PATIENTS ABOUT TO BECOME EDENTULOUS

For the first category of complete denture patients, the tragus-ala line is disregarded for obvious reasons. Its use in establishing centric occlusion in the second category of complete denture patients is mandatory.

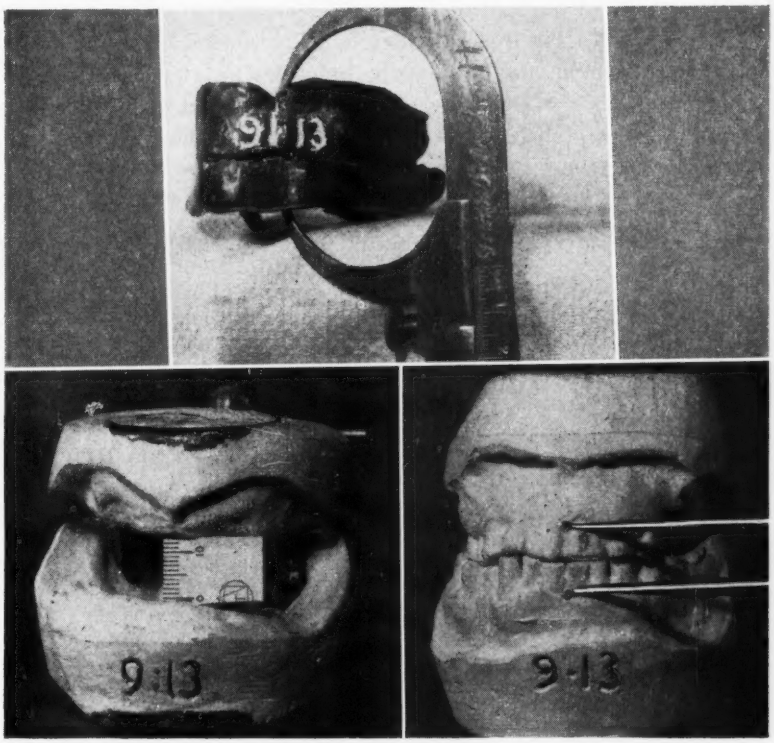

Fig. 10.—A complete denture case in the second category showing the recovery of prosthodontic dimensions from control casts.

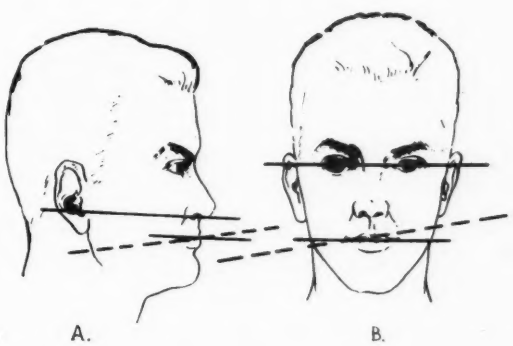

Fig. 11.—The tragus-ala line sketched to show paralleled plane of occlusion. The dotted lines indicate errors.

The tragus-ala, or Campers line, has been used for more than a century by anthropologists, and should be regarded as constant (Fig. 11). It is used by prosthodontists as a guide to the arbitrary plane of occlusion.

The elevation of the plane of occlusion (in millimeters) is taken from the length of the maxillary central incisor and transferred to the maxillary occlusion rim. The occlusion rim is heated and paralleled with a soft tissue penciled line drawn on the face from the lower border of the external auditory meatus to the ala of the nose. With the maxillary plane of occlusion established, it is equalized on a glass slab and notched for the reception of its mandibular component. The mandibular occlusion rim is heated, brought to the millimeter number recorded on the control cast, and reproduced on the outside caliper (Fig. 10).

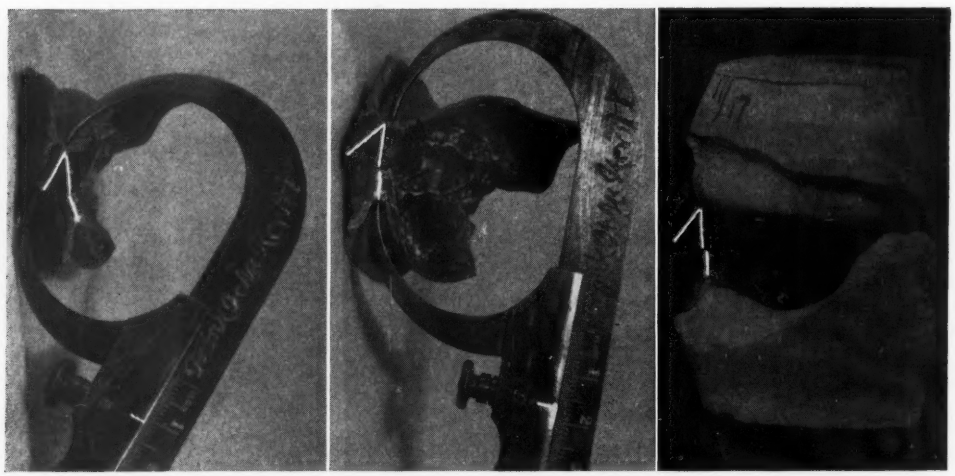

Fig. 12.—Sagittally sectioned modeling compound occlusion rims designed to show the hypotenuse, base, and perpendicular of a triangle. The hypotenuse represents the length of the maxillary central incisor, the base represents its relation to the plane of occlusion, and the perpendicular represents its vertical relation to the incisive papilla or the true elevation of the plane of occlusion. As a separate entity, this dimension is integrated with the height of the interridge crestline space, which is measured from the incisive papilla to the median line of the mandibular ridgecrest.

SECTIONED COMPOUND OCCLUSION RIM

The maxillary and mandibular compound occlusion rims are sectioned sagittally to show the relationship of the incisive papilla to the plane of occlusion as a separate geometric entity, and also to show the vertical dimension of the interridge crestline space as another distinct step in establishing centric occlusion (Fig. 12).

It should be noted that the labial surface of the maxillary central incisor in situ inclines labially and represents the hypotenuse of a triangle, the base of which coincides with the plane of occlusion.

Its perpendicular denotes the true vertical dimension of the elevation of the plane of occlusion taken from the incisive papilla to the simulated incisal edge of the maxillary occlusion rim.

COMPLETE DENTURES FOR PATIENTS WITH OLD DENTURES

Complete denture patients in the third category usually request the renewal of their dentures. When and if their dentures have been satisfactory, they should be reproduced and given the same vertical dimension in millimeters as the old ones. When complete dentures are well made and the ridges have been properly prepared for their reception, usefulness and permanence of the supporting structure is enhanced.

Fig. 13.—There should be no digression from the papilla as a gauging point for the measurement because of uneven ridgecrests.

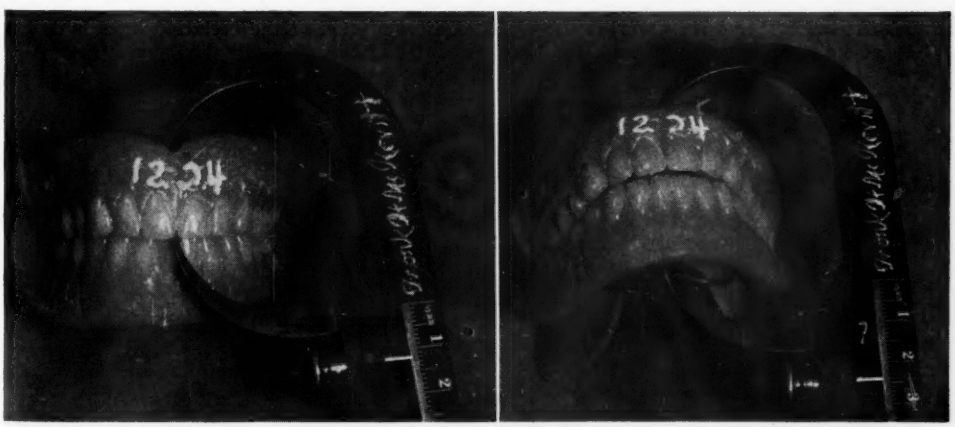

Fig. 14.—Complete dentures in the third category, illustrating the method of recapturing the elevation of the plane of occlusion and the height of the interridge crestline vertical dimension.

Occasionally, patients will appear with alveolar ridges that have undergone atrophic and hypertrophic changes that militate against successful denture wearing (Fig. 13).

These patients require a composite diagnosis including roentgenograms and study casts. The roentgenograms may reveal serrated mandibular ridges, impacted teeth, root tips, and forms of malacic disease of bone.

The study casts will disclose a miscellany of grotesque forms that have evolved from atrophic and hypertrophic metamorphoses (Fig. 14). Principal among them

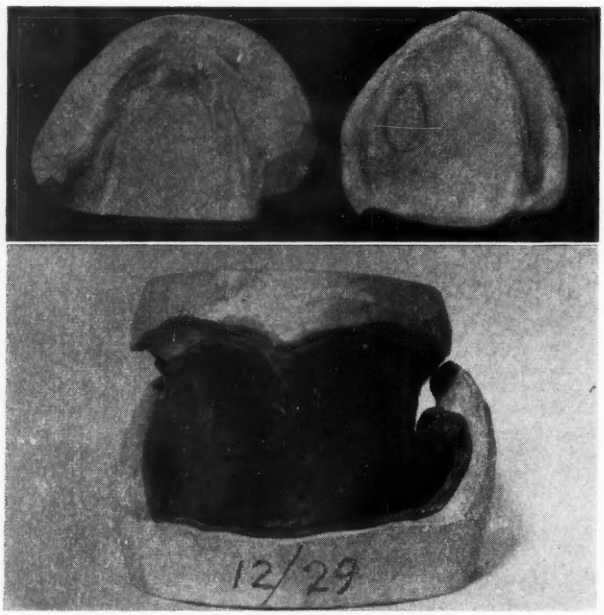

Fig. 15.—Examples of casts occurring in the fourth category and the modeling compound occlusion rims. There was no previous record of the elevation of the occlusal plane or heights of space height for this patient. It must be re-established arbitrarily.

Fig. 16.—*Right,* A normal skull and interridge crestline space. *Left,* An edentulous mandible and maxillae with a large interridge crestline space. Note the concave superior border of the body of the mandible. Compare the locations of the mental foramina with those of the normal skull.

are: high and sharp mandibular ridges, serrated maxillary and mandibular ridges surmounted with soft tissue that can be moved with digital or denture pressures, torus mandibularis and maxillary sharp mylohyoid ridges, hypertrophic maxillary tuberosities of the soft tissue that extend to the superior border of the body of the mandible, bulbous bony tuberosities, and, finally, a uniform atrophy of bone and soft tissue that permits the palpation of the inferior dental nerves and mental foramen on the superior border of the mandibular ridge. These nerves should never be excised. They should be relieved in the same manner as bony prominences are relieved. Gross manifestations of atrophic and hypertrophic forms of the ridges should be reduced surgically.

COMPLETE DENTURE PATIENTS WITHOUT DENTURES OR RECORDS

The most baffling complete denture patients fall in the fourth category. The patient appears without dentures, control casts, or any record of pre-extraction conditions (Fig. 15).

In such cases, the maxillary occlusion rim is contoured to the face, and marked at a point 1 mm. above the upper lip line when it is in repose. The occlusion rim is adapted to the tragus-ala line to establish the maxillary plane of occlusion (Fig. 16). The mandibular occlusion rim is similarly marked 1 mm. below the lower lip and closed, when heated, to the maxillary plane of occlusion to establish an arbitrary height of the space.

When recovering lost prosthodontic dimensions, it should be constantly kept in mind that the temporomandibular articulation, the plane of occlusion, and the height of the interridge crestline space have reciprocal dependence, one upon the other, in order to maintain equilibrium.

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CENTRIC OCCLUSION AND JAW RELATIONS AND FALLACIES OF CURRENT CONCEPTS

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OCCLUSION IS THE MEETING ground of all phases and specialities of dentistry. The confusion and misunderstanding of occlusion and maxillomandibular relation is appalling. This sad situation is due to the inability to determine, reproduce, and maintain accurately the normal relationship of teeth and jaws, and to the lack of understanding of the true functional movements of the stomatognathic system. The concepts of occlusion which are not functional and include the multitude of static theories of so-called anatomic and balanced occlusion have contributed to this confusion. Orton and Lischer,[1] in their investigation of 2,982 students examined, stated: ". . . less than 5 per cent presented teeth which are usually called 'normal,' . . . our investigation also shows that 'the normal does not exist in nature for man's judgment, but is created by him.'" They quote Paul W. Simon as saying, ". . . the true character, or nature of the norm-concept is best understood if we conceive it as a fiction."

The antiquated ideas of balanced occlusion, such as right and left lateral and protrusive movements, condylar and incisal guidances, Bennett movement, together with the Hanau "laws of articulation," and the use of face-bows, should be reexamined in view of recent research and perhaps deleted from teaching in our dental schools. These static articulator movements and positions are based upon physical and geometric laws that are not truly functional and should be substituted for by methods that abide by the physiologic laws of function as seen in the mouth during incision, mastication, and speech. Young[2] states that ". . . much of the trouble encountered has been caused by the attempt to incorporate the present concept of balance, rather than by failure to attain it." Boswell,[3] Kurth,[4,5] Craddock and Symmons,[6] Jankelson, Hoffman, and Hendron,[7] and others originated or support the newer concepts. Jankelson and Kurth show conclusively that there are no functional movements such as right lateral, left lateral, or protrusion during mastication.

Another great cause for confusion regarding maxillomandibular relations was the introduction and development of principles and techniques based upon the physiologic rest position and the free-way space (interocclusal clearance), which should be repudiated entirely in the thinking and the practice of dentistry.

Disagreements in maxillomandibular relation are brought to your attention together with the means for getting out of this maze of confusion. The intraoral

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central bearing device is an important means of determining the horizontal relation of the mandible to the maxillae through the use of the resultant biting point caused by the direction of the resultant forces of the closing musculature. The incorporation of the resultant biting point on an intraoral central bearing device with the author's methods of measuring and controlling vertical dimension[8] by means of tattoo dots on the alveolar ridges and the closest speaking space solves the age-old problem of obtaining an exact centric occlusion.

THE RESULTANT BITING POINT IN OBTAINING CENTRIC OCCLUSION AND JAW RELATION

The method of determining the horizontal relation of the mandible to the maxillae in the centric maxillomandibular relation is through function of the closing musculature. Wilson[9] shows that the direction of the resultant action of the closing muscles (masseters, internal pterygoids, and temporals) is at right angles to the occlusal plane. He did not combine with the effect of these muscles, the effect of the combined action of the suprahyoid muscles and some of the extrinsic tongue muscles. Kurth[5] shows that the resultant direction into centric occlusion from a functional chewing stroke is always forward and upward. Lammie and Osborne[10] describe the pull of the combined action of the elevators of the mandible as upward and slightly backward. Nevertheless, the general upward movement of the mandible causes a resultant biting point on the lower disk of the Coble intraoral central bearing device (Fig. 4). This furnishes a means of determining the exact horizontal relationship between mandible and maxillae. The Coble intraoral central bearing device[11,12] can be incorporated with any technique of building complete dentures.

Fig. 1.—A preliminary centric maxillomandibular relation with wax occlusion rims. Note the lip line which guides the vertical setting of the upper incisal edges. The lower cast is permanently mounted on the articulator with stone, and the upper cast is temporarily mounted with plaster in order to assemble the intraoral central bearing device.

When you reach the step where the preliminary centric maxillomandibular relation is determined with occlusion rims (Fig. 1), the casts are mounted on a nonadjustable plain-line articulator with an incisal guide pin. To fit in with other techniques, the casts could be mounted on any kind of anatomic or nonanatomic articulator and conform with its method of occlusion of the teeth. The lower cast is mounted with stone. The upper cast is mounted with plaster because it must

be removed at the next step. The bridge portion of the intraoral central bearing device is mounted on the lower wax occlusion rim, and the stylus portion is attached to the upper shellac baseplate from which the wax rim was removed (Fig. 2). This central bearing device is placed centrally, generally in the second bicuspid to first molar areas, to avoid tipping of the bases from their foundations.

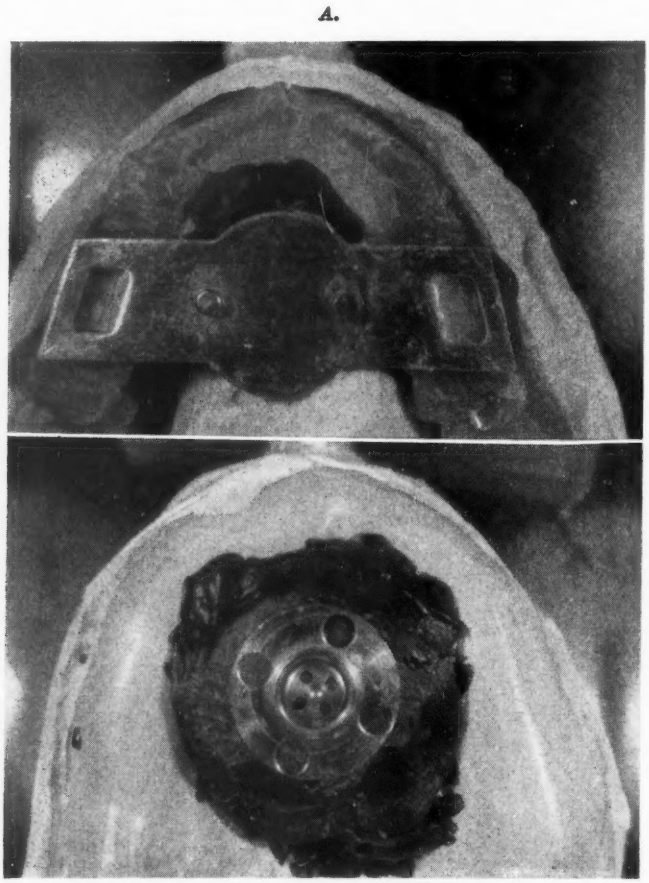


Fig. 2.—*A*, The bridge portion of the Coble intraoral central bearing device on the lower wax occlusion rim. *B*, The stylus portion of the Coble intraoral central bearing device on the upper shellac baseplate. The preliminary wax occlusion rim was removed to allow the subsequent procedures as seen in Figs. 3, 4, 5, and 6.

These devices are then placed in the patient's mouth and adjusted to the established vertical dimension (Fig. 3). The patient is told to bite or repeatedly tap the upper pin against the lower base. *Contrary to present day teaching, the patient is not told to close lightly. He is told to bite hard, bite with dynamic energy and pressure. This biting force develops the normal functional direction of the resultant forces of the closing musculature to place the mandible in the most retruded functional position in relation to the maxillae.* A mark is made on the aluminum disk which is the biting point caused by the direction of the resultant forces of the closing musculature. The lower occlusion rim is removed, and an indentation

is cut into the resultant biting point with a number two round bur (Fig. 4). This accentuates the biting point, and when the lower occlusion rim is replaced in the patient's mouth, there is a locking at this point. This indentation is negligible and does not materially affect the vertical dimension. If there should be a reduction of vertical dimension during this procedure, it can be adjusted to predetermined levels by measuring between the tattoo dots on the residual ridges. The indentation into the resultant biting point insures that there is no movement away from this maxillomandibular relation while the upper and lower recording bases are related

Fig. 3.

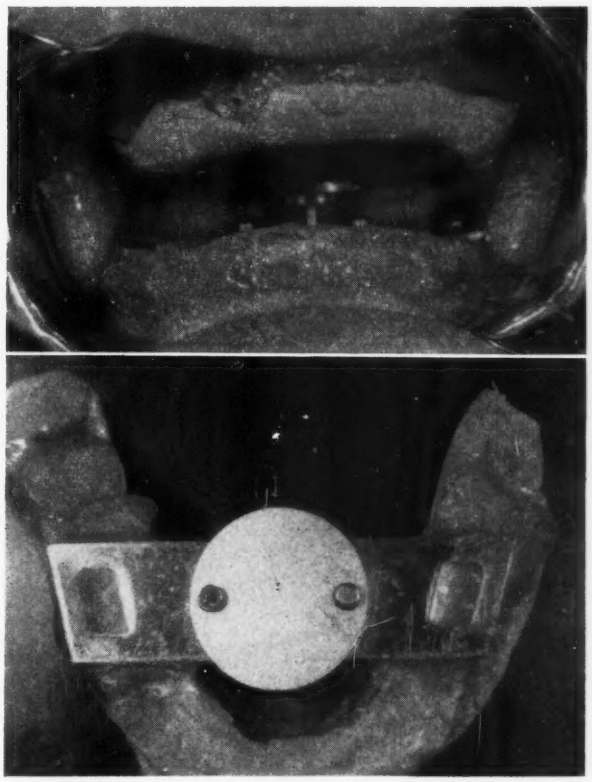


Fig. 4.

Fig. 3.—The assembled Coble intraoral central bearing device retains the jaws at the established vertical dimension. The patient repeatedly taps or bites hard to obtain an exact centric occlusion. Note the labial opening in the upper shellac baseplate to expose the tattoo dot on the residual ridge. The measurement between tattoo dots on the upper and lower ridges controls the vertical dimension measurement with millimeter accuracy. The central bearing stylus can be adjusted during this phase of treatment to increase or decrease vertical dimension to a predetermined level.

Fig. 4.—The resultant biting point produced by the closing musculature while tapping or biting the upper stylus against the lower aluminum disk with force. An indentation with a number two round bur is cut into this resultant biting point. The most posterior functional relation of the mandible to the maxillae is obtained with the elimination of the anterior or posterior translatory movement of the condyles. This is the horizontal relation of an exact centric maxillomandibular relation.

to each other with quick-setting plaster (Fig. 5). The occlusion rims are then replaced on the casts, and the upper cast is remounted with stone (Fig. 6). The exact centric maxillomandibular relation is now present on the articulator for the setting of the teeth.

Fig. 5.

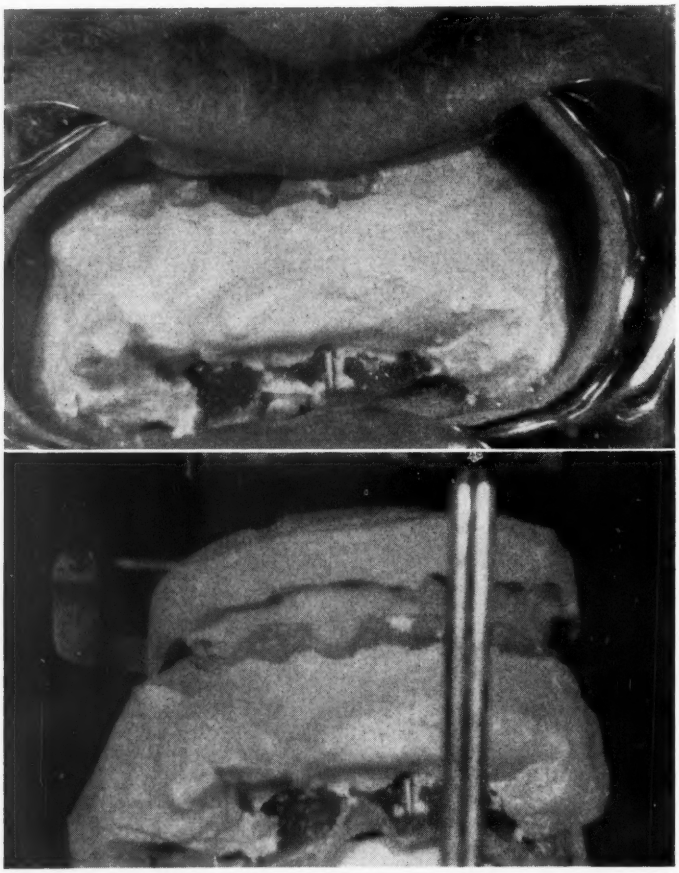


Fig. 6.

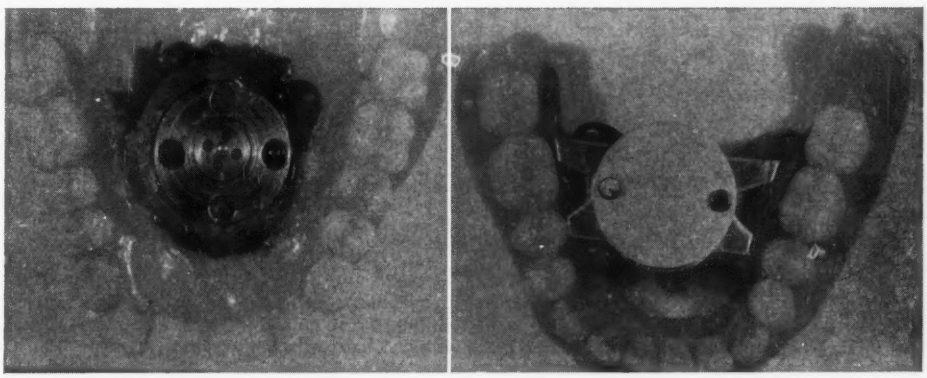
Fig. 5.—The upper baseplate and lower occlusion rim are fastened together with quick-setting plaster. This holds the centric maxillomandibular relation for mounting on the articulator.

Fig. 6.—The upper temporary plaster mounting was removed to allow a final stone mounting of the centric maxillomandibular relation on the articulator. An articulator with an incisal guide pin must be used to allow the remounting of the dentures after processing to control any increase in vertical dimension.

With the use of the intraoral central bearing device, the pressure of the upper pin or stylus against the lower base pushes the upper base solidly on its foundation, and the lower base solidly on its denture foundation. This allows an accurate establishment of an equilibrated occlusion in centric maxillomandibular relation.

One day to several weeks after the insertion and settling of the dentures, it is advisable to remount the intraoral central bearing device on the completed dentures (Fig. 7) to check for deflective occlusal contacts. The pin is turned up

sufficiently to separate the upper and lower teeth (Fig. 8). It is then gradually turned down about one-fourth turn at a time and tested with carbon paper to find the deflective occlusal contacts. During this process, the patient is requested to bite with force, or repeatedly tap the teeth together only in an up and down direction. This is repeated until the upper and lower teeth are together in uniform and maximum contact. This contact is a clinically perfect equilibration of the upper and lower teeth into an exact centric occlusion. *An equilibrated centric occlusion is considered by the author as balanced occlusion* because it is as Jankelson[7] states, "the only tooth contact of any significance that occurs during stomatognathic function."



A. *B.*

Fig. 7.—*A*, and *B*, The Coble intraoral central bearing device is mounted on the completed dentures after insertion and initial settling.

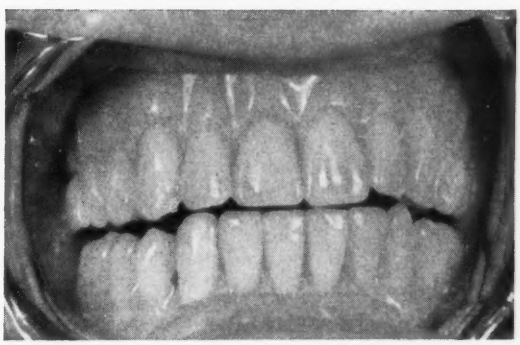
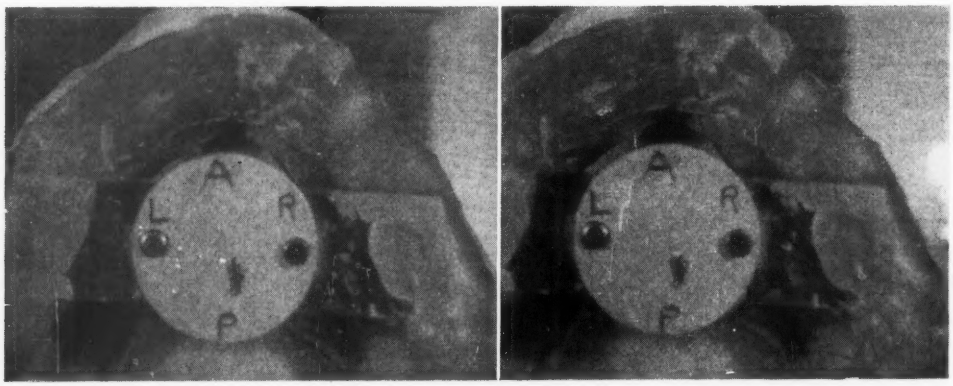


Fig. 8.—The completed dentures with the stylus of the intraoral central bearing device are adjusted to separate the upper and lower teeth. Gradual lowering, up and down tapping, or biting hard on carbon paper locates the deflective occlusal contacts and prematurities. A clinically perfect centric occlusion is thus obtained by the use of the resultant biting point.

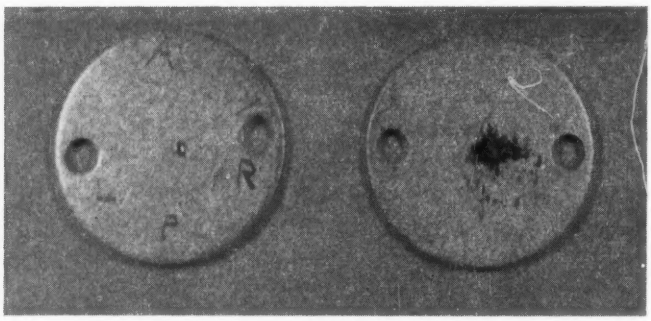
In some cases, a small glide of about 2 to 3 mm. may be noted on the lower disk, instead of the usual pin-point mark. In such cases, it is advisable to place the indentation with the round bur at the retruded position of the mandible or the anterior end of the glide mark (Fig. 9).

There are exceptional patients who, especially those who have been edentulous with no artificial teeth in the mouth for a considerable length of time, seem to lose their normal resultant muscular action. They bite in all directions, particularly in a forward position. If it is impossible to obtain a resultant biting point or a clear-cut anteroposterior glide mark, flat posterior teeth should be used.



A. *B.*

Fig. 9.—*A,* An anteroposterior glide is obtained on some patients while tapping or biting, instead of the usual resultant biting point. *B,* An indentation is made at the anterior end of the glide which is the most retruded functional position of the mandible. This indented point is the horizontal position of centric maxillomandibular relation or centric occlusion.



A. *B.*

Fig. 10.—*A,* Exaggerated markings are made on the Coble aluminum disk in an attempt to equilibrate the finished dentures. The patient who was edentulous for 3 months lost the ability to chew normally with the loss of the normal resultant muscular action of the closing muscles. *B,* The resultant biting point caused by the regained resultant muscular action of the closing muscles. The patient learned to chew in about 2 months, at which time the centric occlusion was equilibrated as is evidenced by this resultant biting point as well as clinical observation.

After they regain their normal muscular action and a resultant biting point or a definite glide mark is obtainable with an assurance of a perfect centric occlusion, anatomic teeth can be used safely in subsequent dentures. Fig. 10*A* shows markings caused by repeated closures with completed dentures one week after insertion. The dentures had been made after a 3-month healing period, during which time the normal resultant muscular action of the closing muscles was lost. Fig. 10*B* shows a definite resultant biting point after the dentures had been used

for 2 months. During this time, the patient learned to chew normally, with the return of a normal resultant muscular action of the closing muscles. Occasionally, it is helpful to have the patient's head bent backwards to avoid protrusive movement of the mandible during the establishment of centric maxillomandibular relation.

Painful areas on the mucosa of the basal seat can cause a proprioceptive reaction with the placement of the mandible in positions away from centric occlusion or centric maxillomandibular relation. This is noted particularly in patients with postoperative sore areas. Immediately after a denture adjustment, the patient can bite hard comfortably and repeatedly tap into clinically perfect centric occlusion. Because of this, the technique of using the resultant biting point on an intraoral central bearing device should be accomplished with occlusion rims or with completed dentures when the underlying tissues are painless and comfortable. This assures the accuracy of the end results.

CONTROL OF OCCLUSION

Occlusion is controlled by the direction of the resultant forces of the closing musculature and not by the hinge axis of the temporomandibular joint. The hinge axis action just happens to occur at the end position of the condyles after the muscles place the mandible in centric maxillomandibular relation. The hinge axis is an effect and not the cause. The resultant forces of the closing musculature have been used through the years in obtaining centric relation and centric occlusion. The value of these forces has been lost in the confusion of occlusion with the emphasis placed on static positions and movements of articulation techniques based upon the physiologic rest position, the free-way space, and the many other inadequacies of maxillomandibular relations. Brown,[13] Schuyler,[14] Jankelson,[15] and others use the direction of the resultant forces of the closing musculature, clinically, by directing the patient to bite into interocclusal wax to locate prematurities or deflective occlusal contacts while determining centric relation and centric occlusion. The "mush bite"[16] puts into action the resultant closing forces and was first used to determine jaw relationships. Standard[17] uses the biting point in some cases in which the needle point (Gothic arch) tracing is indefinite and difficult. The use of interocclusal records in remounting dentures on anatomic articulators takes advantage of the direction of the resultant forces of the closing muscles. An accurate centric relationship of the jaws is thus obtained with the interocclusal record, providing the denture bases are stable on their foundations.

The only tooth contact under total closing muscular force during function occurs in centric occlusion. There is a space between the upper and lower teeth in other functional positions of the mandible. Not all closing muscles enter into the nonfunctional contacts of eccentric "doodling" of the upper and lower teeth. This tends to reduce the muscular forces from pathologic stresses to stresses within the limits of physiologic tolerance in normally healthy individuals.

Two methods of study were used to learn that the closing muscles are the principal factors in determining the terminal occlusion or the terminal relationship of the mandible to the maxillae. One was the experience with my own denti-

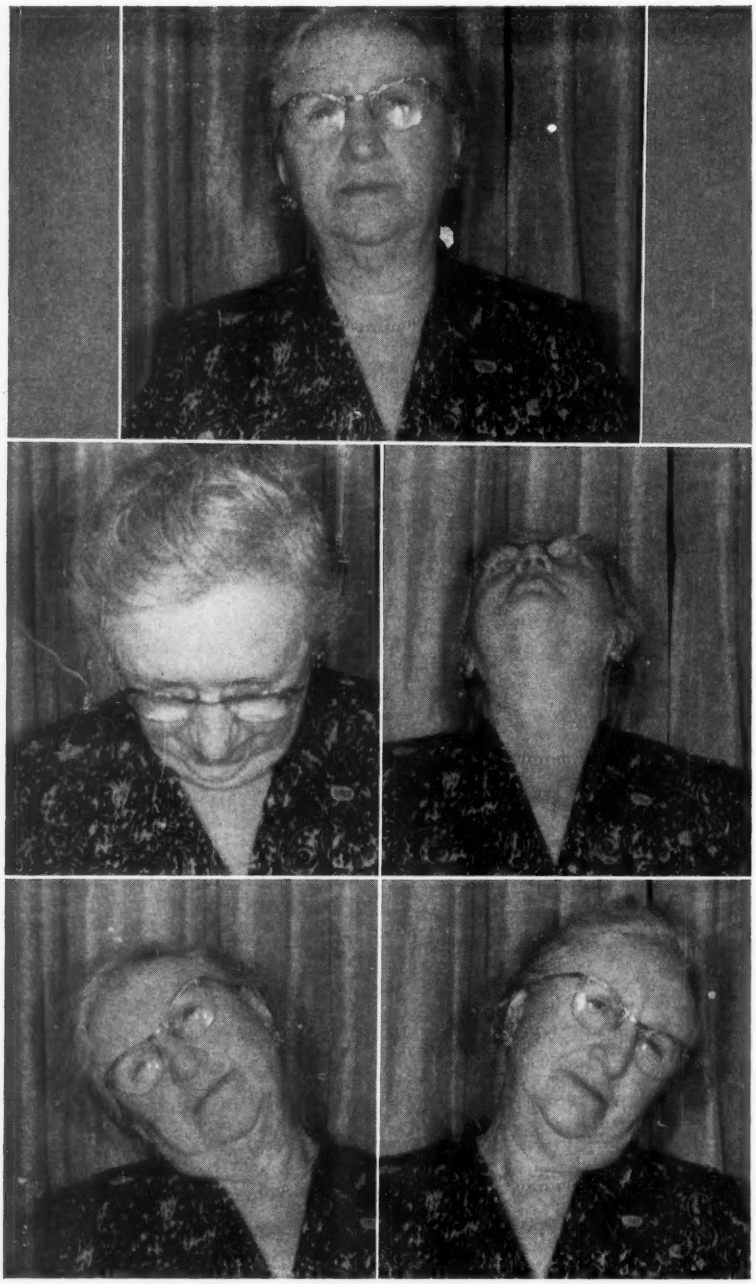


Fig. 11.—Proof that the direction of the resultant forces of the closing musculature and *not* the hinge axis or condylar action is the directing cause of centric occlusion. There is a single resultant biting point with all positions of the head caused by the effect of the closing musculature. In any head position, there is repeatedly one terminal closure into a single centric occlusion with tapping or hard biting.

When closure is made in these same head positions with no muscular effort, with or without the guiding help of the fingers holding the chin, there are many contact positions between the lower and upper teeth. The condylar action is an auxiliary to occlusion and not the directing cause of terminal occlusion.

tion, and the other was the clinical use of the resultant biting point on the intraoral central bearing device.

In 1948, I used my dentition as a subjective experiment in "opening the bite." A Hawley retainer with the lower anterior teeth striking the upper anterior plane was used. This kept the posterior teeth separated. The posterior teeth elongated through continuing eruption, and this increased the occlusal vertical dimension. This increase in vertical dimension was found to be a mistake, and it was gradually reduced by grinding the teeth to restore the original vertical dimension. The teeth were not in normal occlusion during a period of over 7 years of adjustments. There finally was a deflective occlusal contact between the upper and lower left second molars which contacted first, and then the mandible was deflected slightly to the left. This provided an opportunity to study the functional movements of closure in my own mouth. When biting or tapping the teeth together with force, the first occlusion was always on the same deflective contact, and the mandible would then move to the left upon further closure to stop in an eccentric occlusion. When closing slowly, with strong muscular contraction, the same prematurity was noted in centric occlusion, followed by a final deflection to the left into an eccentric occlusion. The same sequence occurred when the upper and lower teeth touched after yawning and in swallowing. The same deflection occurred when I was biting rapidly or tapping the teeth together with the head erect, or bent to the right, to the left, forward, or backward (Fig. 11). The same deflection occurred when I was lying down with the head turned in any direction. This indicated that the musculature is the controlling factor in closing the mandible to occlusion in centric maxillomandibular relation or centric occlusion. To test these observations, try this same experiment on yourself. Repeatedly bite hard or tap the teeth together, swallow, or yawn with your head in all of these various positions, both while erect and lying down. Your teeth will always close into their centric occlusion.

It is simple to observe there is only one horizontal position of centric occlusion and centric maxillomandibular relation. After placing an intraoral central bearing device on occlusion rims or on completed dentures, request the patient to continue tapping jaws together in an up and down direction with the head erect, then bent forward, backward, to the right, and then to the left (Fig. 11). The pin-point mark will be the same with all positions of the head. This mark is generally about 0.5-1.0 mm. in diameter because of the size of the end of the stylus on the central bearing device. This is ample proof that the closing muscles are the controlling factor in elevating the mandible into centric occlusion or centric maxillomandibular relation.

To observe that the hinge axis of the temporomandibular joint is not the controlling factor of occlusion, try the following experiment on yourself. Let the jaws close together slowly with no muscular effort with the head erect, forward, backward, to the right, and to the left as in Fig. 11. Note the different contacting positions of the lower to the upper teeth. With the fingers holding the chin and with an absence of closing muscular effort, guide the mandible to occlusion with the head again in these various positions. Note the different contacting positions of the lower to the upper teeth. This should be ample proof that

the hinge axis or any condylar action of the temporomandibular joints, the ligaments, and the teeth are only auxiliaries, or accommodations to occlusion and have no directing action on occlusion itself.

Schwartz[18] shows a patient with a bilateral condylectomy who closes repeatedly into centric occlusion. This also indicates that the closing muscles are responsible for terminal occlusion and not the temporomandibular joint and any hinge axis position.

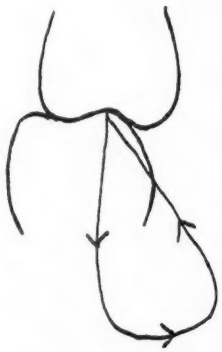


Fig. 12.—The masticating cycle in the frontal plane. The mandible drops in an inferior direction and then moves laterally on the chewing side and then upward and medially toward centric occlusion.

The terminal position of occlusion, as dictated by the contraction of all closing muscles, is centric occlusion. It is the only position dealt with in the arrangement and function of the teeth. Therefore, all occlusal forms of posterior teeth can be used, as well as all types of articulators. The steepest cusps can be arranged by these methods on a simple nonadjustable plain-line articulator with an incisal guide pin to control the vertical dimension during the building of the dentures. The only requirement is the use of the terminal position of centric occlusion which is the final goal of the advocates of all techniques.

It is an obligation of the clinicians and teachers of prosthetics to eliminate all excess techniques to find the quickest methods of producing the most accurate end results. This keeps the cost of dental care as low as possible and the health of the remaining oral tissues as high as possible. Therefore, the involved procedures in the use of anatomic articulators are a luxury in wasted time.

MASTICATING CYCLE

The masticating cycle as described by Hildebrand,[19] Shanahan,[20] Kurth,[21] Boswell,[3] and Jankelson, Hoffman, and Hendron[7] is composed of an elliptical or teardrop type of movement as observed in the frontal plane. The portions of the composite masticating cycle in its sagittal and horizontal planes are not being considered in this analysis. From centric occlusion, the mandible drops in an inferior direction and then moves laterally on the chewing side and then back upward and medially toward centric occlusion (Fig. 12).

It is possible to note the nature of the lateral stroke by observing a patient chewing food. When the bolus of food is placed on the occlusal table by the tongue, the movement of the mandible to the chewing side of the mouth can be noted, along with the execution of the lateral stroke (Fig. 13). If the bolus of food is transferred to the opposite side of the mouth by the movement of the tongue, the mandible moves to the opposite side with the execution of the lateral stroke toward that side. There seems to be bilateral chewing in all patients under observation. Even in patients with very large vertical overlaps, bilateral mastication is observed, with chewing on one side for some strokes and then on the other. Bilateral mastication is reported by Avery and Avery,[22] Gysi,[23] Frechette,[24,25] Stromberg,[26] McLean,[27] and Yurkstas and Emerson.[28] It is interesting to note, in Jankelson, Hoffman, and Hendron's,[7] and Stromberg's[26] research with strain

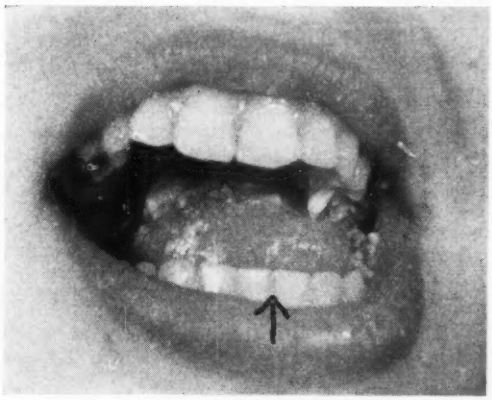


Fig. 13.—The lateral stroke of the masticating cycle is correlated to, and simultaneous with, a lateral movement of the tongue in the same direction during the placement of the bolus of food (peanuts) on the chewing surfaces. Note that the lower midline is lateral to the upper midline.

gauges, the registration on the oscillograph alternates from right to left, which indicates that chewing is concentrated on one side at a time depending upon which occlusal table the tongue places the bolus of food. At this same time, food is masticated to a lesser degree on the opposite side which, in effect, is bilateral mastication. The tongue moves laterally to place the bolus of food on the occlusal table. The lateral stroke of the masticating cycle is correlated to, and simultaneous with, the lateral movement of the tongue (Fig. 13). Thus, the bolus of food is correctly placed on the principal chewing side of the jaws and teeth. The lateral mandibular movement is caused by muscular action in a direction in harmony with the intrinsic muscles of the tongue during the placement of the food bolus on the occlusal table. Jankelson shows that, with food in the mouth, the lateral stroke ends in the vicinity of, and just short of, centric occlusion. With the absence of food in the mouth, the terminal position of simulated chewing is exactly in centric occlusion.

Because the lateral stroke occurs during the function of mastication of food, it can be considered an unimportant part of the masticating cycle and not considered in the location of the terminal position of occlusion. The up-and-down stroke of the masticating cycle can be utilized by biting repeatedly with force, or tapping the opposing parts of the upper and lower portions of an intraoral central bearing device to mark the resultant biting point to obtain the only centric occlusion.

CONFUSION OF CENTRIC RELATION

There is considerable misunderstanding of centric relation as it is used in referring to the relationship between the mandible and maxillae.

It is now generally agreed that centric occlusion and centric relation must coincide. Disharmony between centric occlusion and centric relation of dentitions is not as common as some clinicians may believe. The supposed disharmony is due to the translatory movement of the condyles in a protrusive or a retrusive direction from centric occlusion to physiologic rest position. Because of this complication of translatory movements in some patients, many occlusions are rehabilitated and equilibrated incorrectly.

The following definition[29] should be deleted from the Glossary of Prosthodontic Terms: "Centric relation [is] the most retruded relation of the mandible to the maxillae when the condyles are in the most posterior unstrained position in the glenoid fossae from which lateral movement can be made, at any given degree of jaw separation."

This definition speaks of the position of the condyles in the glenoid fossae. This anatomic area cannot be seen, palpated, or roentgenographed with accuracy. So why have a definition dependent upon an anatomic area which is not only incidental anatomy to terminal occlusion, but is of no clinical significance? It speaks of the condyles as being "in the most posterior unstrained position in the glenoid fossae from which lateral movement can be made." Higley and Logan,[30] in a roentgenographic study of 58 patients, report a posterior translatory movement of the condyles from centric occlusion to physiologic rest position in 29.3 per cent of the patients studied. This posterior movement ranged from 1.0 to 2 mm. which is actually a more posterior *unstrained* position of the condyles in the glenoid fossae than their supposedly "most posterior unstrained position" in centric relation. Therefore, this portion of the definition is inaccurate in a large percentage of patients.

It defines centric relation "at any given degree of jaw separation." Although centric relation and centric occlusion must be at the same vertical level, Robinson[31] and others have defined it, erroneously, at the physiologic rest position level. Therefore, this portion of the definition is contradictory to scientific facts and adds further confusion to jaw relations. The author has proved, with the use of the closest speaking space and tattoo dots on the alveolar ridges, that the vertical dimension must not be increased.[32] We must, therefore, assume that the patient's present vertical dimension of the dentition is normal unless it can be proved scientifically to the contrary. Clinicians who look at casts of a full complement of natural teeth, and remark that "the bite is collapsed, and must be restored about

4 or 5 mm." are working under illusions. They erroneously claim that restoring vertical dimension is not "opening the bite." The clinical measurement of the closest speaking space (which may be far less than 4 mm.) is most convincing to prove that the vertical dimension must not be increased in most patients. Therefore, why must there be a definition of any relationship of the jaws which allows "any given degree of jaw separation"? These superfluous degrees of jaw separation are nonfunctional and pathologic. Centric relation, if it coincides with centric occlusion, is a functional position. Perhaps the inclusion of these variables of jaw separation in the definition is a justification for the wave of "bite raising" efforts in recent years which have been warned against by Tench,[33] Schuyler,[34] Landa,[35] and others. Perhaps it is the justification for the past misunderstanding and inability to obtain an exact vertical dimension.

The protrusive and, in some cases, retrusive movement of condyles from centric occlusion to physiologic rest position has added more confusion to the understanding of centric relation. Alexander[36] has shown that 50 per cent of the 50 patients surveyed cephalometrically moved the mandible as hinges from physiologic rest position to centric occlusion. Over 40 per cent of the patients had a translatory or retrusive condylar movement from physiologic rest position to centric occlusion. Higley and Logan,[30] in their roentgenographic study, allowed the mandible to drop 2 mm. from centric occlusion to the physiologic rest position. The condyles dropped inferiorly from 1.0 to 4 mm. and moved either anteriorly or posteriorly in a translatory movement. The anterior translatory movement from centric occlusion to physiologic rest position of 70.6 per cent of patients ranged from 1.0 to 4 mm. The posterior translatory movement from centric occlusion to physiologic rest position of 29.3 per cent of patients ranged from 1.0 to 2 mm. This posterior translatory movement from centric occlusion to physiologic rest position seems to be a clinical fact, and further research must be done on this phase of occlusion. Ricketts[37] concluded, with the use of laminography, that physiologic rest position is unreliable for orientation of tooth occlusion. He found a similar protrusive translatory movement from centric occlusion to physiologic rest position in 15 per cent of his "normal" patients as well as in his patients with deep horizontal and vertical overlaps of the teeth. Landa[38] dissected cadavers to show the wrinkles in the posterior portion of the capsular ligament which accommodates the physiologic rest position of the mandible. These wrinkles allow a translatory movement of the mandible from centric occlusion to physiologic rest position in some patients. The existence of this translatory movement is concurred with by Kurth,[39] Granger,[40] and others.

There is disagreement regarding the accuracy of the needle point (Gothic arch) tracing in the determination of the horizontal position of the jaws at centric relation. Some clinicians claim that centric relation is at the apex of the Gothic arch. Boos,[41] in his research on maxillomandibular relationship with use of the power point, reports that centric relation is not at the apex of the Gothic arch. I have found by the use of the resultant biting point that the needle point tracing is extremely accurate in some patients, and in others it is unreliable. The resultant biting point has been noted at the apex of the needle point tracing in

some patients, anterior to the apex in others, and also posterior to the apex. Perhaps the latter cases are similar to the 29.3 per cent of patients noted by Higley and Logan[30] who move their condyles posteriorly in a translatory movement from centric occlusion to physiologic rest position. Therefore, it is safer and more accurate to use only the resultant biting point to determine centric maxillomandibular relation.

It is suggested that the badly confused term "centric relation" be deleted from future literature and that the more descriptive term "centric maxillomandibular relation," as used by Schuyler[42] and others, be retained.

This definition is offered: "Centric maxillomandibular relation is the forced terminal relation and the most retruded functional and equilibrated position of the mandible in relation to the maxillae at the normal vertical dimension, caused by the direction of the resultant forces of the closing musculature while biting hard or tapping on occlusion rims, with or without the aid of an intraoral central bearing device."

This definition is offered: "Centric occlusion is the forced terminal contact of the mandibular and maxillary teeth in the most retruded functional occlusal and equilibrated position of the mandible in relation to the maxillae at the normal vertical dimension, caused by the direction of the resultant forces of the closing musculature while swallowing, yawning, biting hard, or the tapping of the teeth together."

FALLACY OF HINGE AXIS

The temporomandibular joint is a sliding hinge joint and is, therefore, capable of many movements as dictated by muscular action and rest. Apparently, there is a hinge axis movement in the final forced closure of the jaws, but the advocates of this movement have run into the complication of the few millimeters of anterior or posterior translatory movement of the condyles from centric occlusion to the physiologic rest position. Whenever the translatory movements of the condyles are present, it is impossible to utilize the physiologic rest position to obtain centric occlusion by a simple closing of the jaws on the hinge axis. Boos[43] mounts the casts on an articulator in the physiologic rest position with the use of interocclusal plaster. The space between casts is reduced 2 mm. on the articulator hinge to obliterate the interocclusal clearance at the level of centric occlusion. This method is excellent in patients who have only a hinge axis movement but not in patients with a translatory condylar movement. For example, in the patients having a protrusive translatory movement of the condyles, the final closure would be in a protruded position in relation to that of centric occlusion. Lindblom[44] and others use a similar method with the use of interocclusal wax.

The contradiction from theory to practice of the hinge axis advocates must be explained. Because of the condylar translatory movement in some patients, it is not advisable to use the physiologic rest position to obtain centric occlusion through the medium of the hinge axis. Nevertheless, this is routine with these clinicians. McCollum[45] tells the patient to let the mouth drop open and then uses a rhythmic closing and dropping open to establish the hinge axis of the mandible at centric occlusion. Eberle[46] determines the hinge axis with a quick open

and close rhythmical manner, using a chop chop motion. For complete dentures, he requests the patient to close down into the wax of the occlusion rims hard enough to force the mandible 3 or 4 mm. closer than the rest position distance. Lindblom,[44] Granger,[40] Page,[47] and others use interocclusal wax or other materials for these records. When the patient closes, or even bites lightly into these materials, or uses a closing, biting, or chopping motion with natural or artificial teeth, or with occlusion rims, the closing musculature will generally exert sufficient force to bring the mandible into the most posterior functional position and obliterate any anterior or posterior translatory movement of the condyles. The mandible is now in its most retruded functional position as dictated by the effect of the closing musculature and not by the subservient temporomandibular joint. The advocates of the hinge axis believe in the erroneous theory that the temporomandibular joint is the controlling factor in occlusion, but in practice they use the resultant forces of the closing musculature to give them their successful end results.

THE FREE-WAY SPACE IS INACCURATE

The greatest single cause of so much confusion of maxillomandibular relation is the introduction and discussion of the free-way space of the physiologic rest position by Niswonger,[48] Thompson,[49] and others. This portion of dental history is a normal effort to find the means of measuring vertical dimension and to determine the relation of the mandible to the maxillae. This method is now antiquated due to its inaccuracy and unreliability[50] for attaining its intended results. The use of the physiologic rest position and the free-way space in techniques does not furnish accurate end results. The profession must awaken to the fact that the free-way space and the rest position of the mandible are not necessary in clinical procedures, and any further discussion is merely adding more confusion to jaw relationship.

Muscle *action* and *not rest* of muscles must be used in determining the functional relation of jaws during stomatognathic function. Centric occlusion occurs during swallowing, yawning, biting, or the tapping of the teeth together. These functions are caused by muscles in action. Therefore, it does not make sense to use muscles at rest to determine such a jaw relationship as centric maxillomandibular relation. Other more accurate means are available. Determining the height of vertical dimension when the muscles of the mandible are at rest or in balanced tonus is no more accurate than determining a person's height when all the body muscles are at rest or in balanced tonus during sleep. To measure a position caused by muscle action, that portion of the anatomy must be put into muscle action.

Many advocates of the physiologic rest position use phonetics or action of muscles to aid in determining a rest position of the mandible. They mix action and rest, which are contradictory. Gillis,[51] Eberle,[46] and others, use the sound *M* to aid in obtaining the proper rest relation of the jaws. The author[52] has shown that *M* causes a wider space between the upper and lower jaws, and experience has shown that phonetic sounds causing the wider levels between the jaws are

inaccurate and cannot be relied upon. When phonetics are used, the vertical dimension is determined by the measurement of the closest speaking space[53] using the sibilants only, such as *s, sh, z, zh, ch,* and *j,* in such words as ye*s,* bu*zz,* fi*sh,* mea*s*ure, *ch*ur*ch,* and *j*ud*ge.* They are consistently accurate.

Many clinicians have noted that the physiologic rest position and its free-way space was difficult to determine and did not furnish scientifically accurate end results. Atwood[54] has shown scientifically, by the use of cephalometrics, that the free-way space measurement is not an accurate procedure. He measured the free-way space before and after the loss of the dentition, with dentures in the mouth and out of the mouth, at the same sitting, and at different sittings. He found there was a variation of size of the free-way space measurements in the same patients. In commenting on Atwood's findings, Boucher[55] stated, "The questions raised by this study will provide much food for thought and possibly a revision of the general concept of rest position and interocclusal distance."

Olsen[56] has accomplished similar research as Atwood's and has arrived at similar conclusions. That the accurate use of the physiologic rest position and the free-way space is questionable is indicated by the excerpts from Olsen's thesis: "Rest position of the same individual without dentures in the mouth varied from 0.3 mm. to 5.7 millimeters in 98.6 per cent of the cases . . . . Measurements of the same individuals with dentures in place varied from 0.1 millimeter to ten millimeters . . . . In comparing the average recorded measurement of rest position of an individual with dentures in the mouth with that of the same individual without dentures, the difference is from 0.2 millimeter to 7.2 millimeters in 97.1 per cent of the cases. The average rest measurement with dentures in place was greater than the comparable measurement without dentures in 82.9 per cent of the cases. Therefore, it is suggested that the resting position of the edentulous mandible is not rigidly stable either with or without dentures in the mouth."

The findings of Atwood, Olsen, and others are contrary to the belief that the free-way space is constant throughout life.

The use of the closest speaking space and tattoo dots on the residual ridges[8] is the answer to the problems of vertical dimension. The use of the resultant biting point is the answer to the horizontal relationship of the mandible and maxillae. These methods solve the problem of centric occlusion and centric maxillomandibular relation. Therefore, the further use of techniques based upon the physiologic rest position and the free-way space in determining jaw relation is not advisable and obsolete.

CONCLUSIONS

1. There is confusion in understanding centric relation and a fallacy in the accepted definition.

2. The term "centric relation" should be replaced with the more descriptive term "centric maxillomandibular relation." This definition describes the relation of the mandible to the maxillae, which is the same horizontal and vertical position as centric occlusion.

3. The direction of the resultant forces of the closing musculature of the mandible is responsible for the single centric occlusion. The hinge axis of the temporomandibular joint does not control occlusion.

4. There is a contradiction between the theory and the practice of the hinge axis advocates.

5. The resultant biting point on an intraoral central bearing device should be used to obtain an exact centric maxillomandibular relation and its exact centric occlusion.

6. In instances where there is a biting glide on the table of the intraoral central bearing device, the forward end of the glide mark should be used. This is the most retruded functional position of the mandible.

7. The resultant biting point is found in various positions in relation to the apex of the needle point tracing. It may be exactly at the apex or in various positions anterior or posterior to the apex. Because the needle point tracing cannot be relied upon in two out of these three groups of patients, it is advisable to use only the resultant biting point to determine the horizontal relation of centric maxillomandibular relation or centric occlusion.

8. An intraoral central bearing device with its resultant biting point should be used on all complete dentures after their insertion and initial settling to equilibrate the centric occlusion.

9. The lateral stroke is disregarded, but the up and down movement of the masticating cycle is the basic movement used for the establishment of occlusion.

10. All forms of posterior teeth can be used with the resultant biting point method. It is suggested that anatomic posterior teeth be used in patients exhibiting a resultant biting point or a clear-cut anteroposterior glide mark on the intraoral central bearing device. Flat posterior teeth should be used for patients who have lost their muscular control as evidenced by tapping in all directions away from centric maxillomandibular relation.

11. All types of articulators can be used with the resultant biting point method. The anatomic articulator is an unnecessary luxury. Only the nonadjustable hinge type articulator with an incisal guide pin is advisable for the most accurate end results.

12. Balanced occlusion, involving right and left lateral and protrusive movements, is nonfunctional and should be re-examined and perhaps discontinued.

13. The new concept of balanced occlusion involves an equilibration of the upper and lower teeth at centric occlusion. This is the only functional occlusion of the teeth during stomatognathic function.

14. Principles and techniques based upon the physiologic rest position and its free-way space are nonfunctional, inaccurate, and antiquated. Further confusion of maxillomandibular relation could be avoided by repudiating entirely their erroneous concepts.

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AN EVALUATION OF CENTRIC RELATION RECORDS OBTAINED BY VARIOUS TECHNIQUES

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A SURVEY OF THE CURRENTLY available literature showed evidence of controversy existing in the field of interocclusal records. Numerous methods of registering centric relation have been described, and considerable criticism has been levied against each method by various authors. Tench[1] wrote that he could "now make the unequivocal statement that the Gysi arrow point technique is the only means that should be used in any practice to establish the most important single measurement taken in the construction of full dentures, the central occlusion relation of the mandible to the maxilla." Trapozzano[2] stated that the (wax) "checkbite method is the technique of preference in recording and checking centric relation. Correctly used, its accuracy is far greater than is possible to obtain with a central bearing point." Moylan[3] wrote, "The apex of the Gothic arch is full of vagaries," whereas the National Society of Denture Prosthetists[4] reported that "the use of the needle point tracing device for the purpose of determining and checking centric jaw relation is recommended as being both scientific and practical. This Society recognizes no other means of verifying centric jaw relationships."

The basic principles of obtaining various maxillomandibular records have been criticized as have also the various techniques based on these principles. Payne[5] has described the intraoral tracer as, "difficult to see and does not work as well where flat ridges or flabby tissues occur. . . . Extraoral tracings provide visibility but retain the other difficulties if central bearing plates are used. The more equipment we put into the mouth, the more difficult it is for the patient." Kingery[6] pointed out several drawbacks in the use of the central bearing point and added that the central bearing point "allows for no control over the amount of closing pressure applied by the patient."

Gysi,[7] in his experiment on the various checkbite methods of recording centric relation, found no two checkbites, that were obtained with wax or compound, alike and commented that, "we found the cause of the error to be that as

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the soft modeling compound which was placed between the jaws to register the relations was compressed by relatively cool bite rims, it cooled much more rapidly where it was thin than where it was thick, became harder, and made unequal pressure on the bite rims." Schuyler[8] stated that when records are made using compound, the uneven or premature contact of areas of occluding surfaces, due to uneven thicknesses or density of occluding rims, may disturb the relation of the record bases. Simpson[9] commented that "such methods as holding the jaw back on closing the mandible, elevating the tongue, and having the patient swallow as he closes the jaw, and the like, are condemned for the paramount reason that they are unscientific and always carry with them the fallacy of guess."

It is obvious from this brief reference to the dental literature that it is extremely difficult for one to evaluate the reliability of one technique over another, because of the lack of sufficient experimental evidence in support of various techniques emphatically recommended by different operators.

METHODS OF RECORDING CENTRIC RELATION

Up until the end of the nineteenth century the "mush-bite" technique[10] was the most commonly used method for recording centric relation. Christensen[11] described the wax method of recording protrusive positions of the mandible. Later, Hanau[12] considered various factors that influenced the recording of centric relation and modified the intraoral wax method. He pointed out the "resilient and like effect" of the denture-supporting tissues, "Realeff," as a source of error in registering the various maxillomandibular relationships in wax. He further advocated making the registrations of the positional relationships under zero pressure in order to minimize the error caused by "Realeff." Wright[13] also pointed out various factors that influenced the intraoral wax records and suggested the use of accurately fitting denture bases when he stated that, "unless subsequent records are made upon identical, or nearly identical, denture bases, the resulting records will not be consistent." He also added that it was impossible to have the patient apply the same amount of pressure on each subsequent record and that it was logical and mechanically correct to make records without pressure, or as nearly as possible with a pressure of zero. Accordingly, records taken under zero pressure could be duplicated consistently, and thus, errors due to biting pressure could be avoided. Modifications in this method of making maxillomandibular records resulted from the use of materials other than wax, such as plaster, compound, and various types of washes.

The wax method of recording centric relation has been criticized by Gysi,[7] Schuyler,[8] Simpson,[9] Stansbery,[14] and others. According to Sears[15] and Hall,[16] the phenomenon of right and left intersection arcs was described and illustrated by Balkwill in 1866. The first known "needle point tracing device" for use in denture construction seems to have been introduced by Hesse, in 1897, and given prominence by Gysi in 1910. Gysi[7] used modeling compound occlusion rims in order to maintain the vertical dimension during the needle point tracing procedures. Phillips[18] pointed out various errors produced by this technique, and stated that, "if one occlusal rim is allowed to touch the other during the lateral

extreme positions, undue pressure is bound to be exerted on the contact side, and on account of the resiliency of the underlying tissues the side not in contact will be unseated just enough to cause a false reading for the horizontal inclination of the condylar path." Smith[19] also pointed out drawbacks in the methods where vertical dimension was maintained by occlusion rims, commenting that, "the contacting surfaces of the bite-rims will not glide easily upon each other, horizontal stresses are set up and the shifting of the bases may easily occur, and, under these conditions, it is difficult for the patient to make accurate recordings."

Phillips[20] introduced the central bearing point to maintain vertical dimension as well as to centralize forces. He stated that the apex of the Gothic arch tracing denoted the correct centric position. His appliance required no attachment between the occlusion rims to make the transfer to certain types of instruments. Stansbery[14] introduced the use of plaster of Paris for attaching the mandibular and maxillary rims in various positions recorded in an extraoral tracing method. Sears[15] devised the Sears trivet, an extraoral device which provided a means of fixing the registered positions extraorally.

Another change in the graphic method resulted when a central bearing point, used for centralizing forces and stabilizing the lower occlusion rim, also served as a tracer to register the intraoral Gothic arch. Various intraoral tracing devices have been described by Blanchard,[21] Messerman,[22] Coble,[23] Hardy,[24] and Wastrow.[25] Hardy[26] introduced a central bearing device with two heads. One end was brass pointed and was used for the recording of the tracing, while the other side consisted of a mounted steel ball bearing which was used as an intraoral balancer for the dentures with nonanatomic teeth set to a flat plane of occlusion.

Various means of locking the tracer at the apex of the needle point tracing have been described. These included a hole or a depression into which the needle point would fall, also a plastic or metal disk[26] which was placed over the apex of the tracing. This served as a convenience and a guide for the patient to hold a "centric" position while the registration was being secured with plaster or some other fixing material.

Another type of intraoral registration was afforded by the Needles technique[27] in which three cutting pins were attached to the maxillary occlusion rim. He suggested the use of a spherical occluding surface on the modeling compound occlusion rim into which the pins would register three simultaneous Gothic arches. Pyott and Schaeffer[28] described a cephalometric roentgenographic technique to register the centric relation and vertical dimension simultaneously. Page[29] advocated the mounting of casts on a special instrument, called a "Transograph," through the use of a hinge axis and hingelike registrations without the guide of a static vertical relationship such as was advocated by the previous authors.

Hight,[30] Sears,[15] House,[31] Terrell,[32] and many others have devised tracing mechanisms of their own design which enable them to secure dependable registrations.

Gysi[7] and Kingery[8] have classified various methods of recording centric relationships. Generally speaking, they may be considered as direct recordings, graphic recordings, functional recordings, and cephalometric determinations. A classification of the various methods of recording centric relation is presented in

Table I. Various factors that influence the recording of centric relationship have been pointed out in the literature. A summary of these factors appear in Table II.

As a result of the obvious lack of quantitative experimental evidence regarding the relative accuracy of commonly used centric maxillomandibular relation records, a study was undertaken to compare the duplicability of records utilizing various techniques.

TABLE I. CLASSIFICATION OF THE DIFFERENT METHODS OF RECORDING CENTRIC RELATION

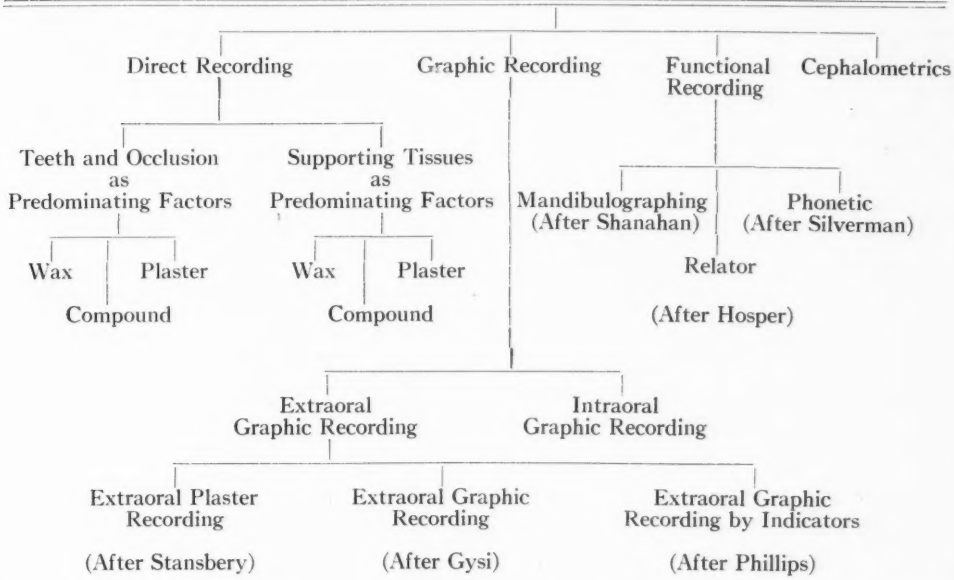

TABLE II. FACTORS INFLUENCING THE RECORDING OF CENTRIC RELATION

1. Resilient action of the supporting tissues
2. Fit of the denture bases — stability, retention
3. Temporomandibular joint and its neuromuscular mechanism
4. Pressure applied in making the record
5. Technique employed in making the record
6. Ability of the operator

METHODS AND MATERIALS

Three standard methods of recording centric relation were selected for evaluation in this study: (1) the intraoral tracing procedure (Hardy), (2) the wax registration procedure (Hanau), and (3) the extraoral tracing procedure (Stansbery).

THE INTRAORAL TRACING PROCEDURE

A horizontal line was drawn along the outside of the mandibular cast parallel to the flat bearing area in the region of the bicuspid and molar teeth. A rim

of modeling compound was constructed on the lower stabilized baseplate so that its occlusal surface was parallel to this line. The vertical height approximated that of the final position of the lower anterior teeth. A stiff brass plate was contoured to the size of the rim and luted to the modeling compound so that it was parallel to the lines marked on the outside of the cast. A central bearing point was attached to the upper stabilized baseplate with modeling compound. It was positioned as closely as possible to the center of the supporting areas of both upper and lower residual ridge arches. In cases where centralization to both maxillary and mandibular arches was not possible, the lower was favored. In all cases, the tracer was placed perpendicular to the tracing plate. Due consideration was made for tongue space.

Fig. 1.

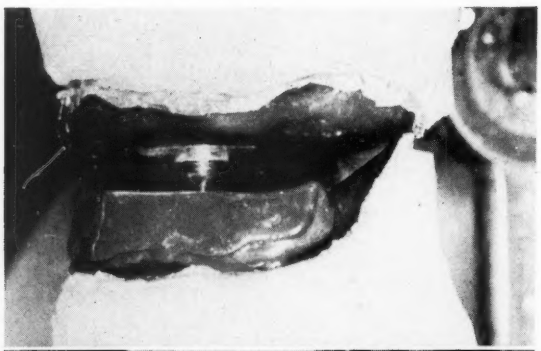

Fig. 2.

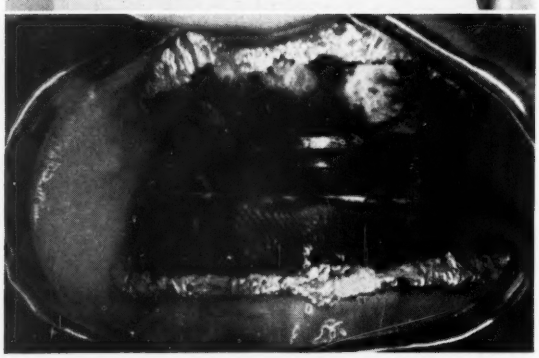

Fig. 1.—The intraoral tracing device.
Fig. 2.—The intraoral tracing device in the mouth.

The central bearing point was adjusted so that it touched the lower plate at the previously determined vertical dimension (Fig. 1). The occlusion rims were then carried to the mouth and checked to ascertain that there was no interference between them during lateral excursions (Fig. 2). A thin film of blue inlay wax was coated on the mandibular brass plate. The patient was instructed to exert extremely light pressure and to move his mandible from left to right with an occasional protrusive movement. A tracing was obtained and considered adequate

when a definite apex could be observed. A disk with a small hole punched in the center was placed so that the apex of the tracing fell in the center of the hole. This was luted in position with sticky wax, and the occlusion rim was returned to the patient's mouth. The patient was then requested to engage this small hole in the disk with the central bearing device and to hold the two baseplates together as lightly as possible. Soft impression plaster was then injected between the two baseplates with a syringe. When the plaster hardened, the occlusion rims were removed in one unit wherever possible.

THE WAX CHECKBITE PROCEDURE

A roll of hard baseplate wax, approximately one-half inch in diameter, was bent into position over the crest of the lower ridge and fixed to stabilized maxillary and mandibular baseplates. The positions of the wax rims were adjusted to the flat bearing portion of the mandibular ridge and were cut short of the slope of the ascending ramus. The original vertical dimension was maintained. The occlusion rims were adjusted intraorally to ascertain uniform contact throughout, with no interference at their distal extremities (Fig. 3). The mandibular rim was shortened approximately 2 mm., and keys were cut into the bicuspid and molar areas of the upper and lower occlusion rims. Two small rectangular pieces of soft beeswax were placed in the molar and bicuspid regions of the lower occlusion rim (Fig. 4). These were pooled with a hot spatula, with care being taken that they approached the same extremely soft consistency. The patient was asked to raise and retrude the tip of his tongue so as to touch the posterior palatal edge of the upper baseplate. The patient was then instructed to close until the proper vertical dimension was reached. The predetermined anteroposterior relationship was checked by means of labial guide lines (Fig. 5). The wax was chilled, and the occlusion rims were removed from the mouth.

EXTRAORAL TRACING PROCEDURE

The methods advocated by Stansbery were used to execute this tracing procedure (Fig. 6). Quick-setting impression plaster was used to fabricate the keys used in this method.

FABRICATION OF STABILIZED BASEPLATES

Gross undercuts on the cast were filled in with Moldine. Single thick shellac baseplates were then adapted over the upper and lower casts and, whenever feasible, they were trimmed short of the undercuts. Tin foil was then burnished over both upper and lower casts with the aid of coton rolls so that no wrinkles were left in the tin foil. A metallic oxide impression paste was then placed inside the baseplate, placed on the tin foil, and allowed to harden. When hard, it was removed from the cast, and the excess tin foil and metallic oxide paste were trimmed away. A separate set of stabilized baseplates was prepared for each of the three methods studied.

SELECTION OF THE SAMPLE

Patients were selected at random from the Prosthetic Clinic of Tufts University School of Dental Medicine. A total of 31 patients were studied. This included 22 patients for whom dentures were being constructed at the clinic and 9

Fig. 3.

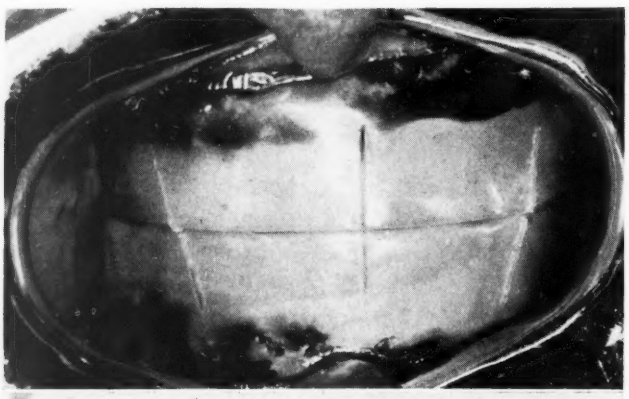

Fig. 4.

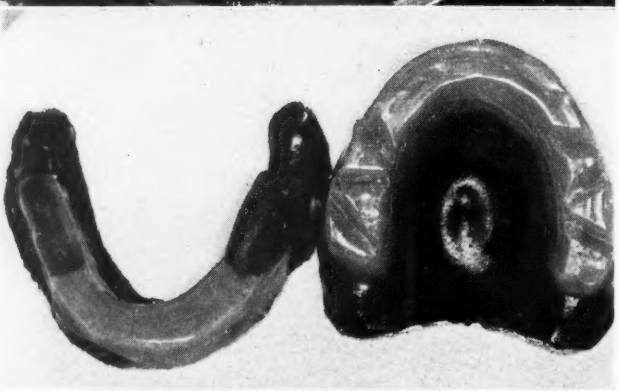

Fig. 5.

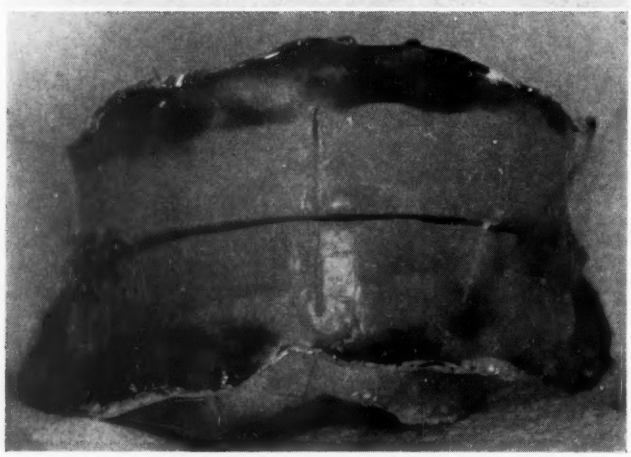

Fig. 3.—Labial guidelines.
Fig. 4.—The keys and wax prepared for a registration.
Fig. 5.—A completed wax registration.

patients who were wearing dentures previously made at this clinic. Patients were grouped according to age and ridge type. The ridge types were classified into well-developed ridges, flat ridges, and flabby ridges. In classifying ridge types into different categories, the following characteristics were considered: (1) height of the ridges, (2) muscle attachments, (3) amount of mobility of the tissue covering the residual ridges, and (4) palate form. Cases that exhibited marked tissue mobility were classified in the flabby ridge group. In differentiating between good and flat ridges, a compromise of the remaining three factors was made. Flat ridges, in general, compromised those where excessive resorption of the residual ridge had occurred. Patients with gross abnormal ridge relationships were not used in this study.

IMPRESSION PROCEDURE

In 17 cases, the impression procedure used to obtain the final impressions followed the method described by Hardy.[21] In 9 patients that were recalled, an alginate impression of the residual ridge was made with the aid of perforated edentulous trays.

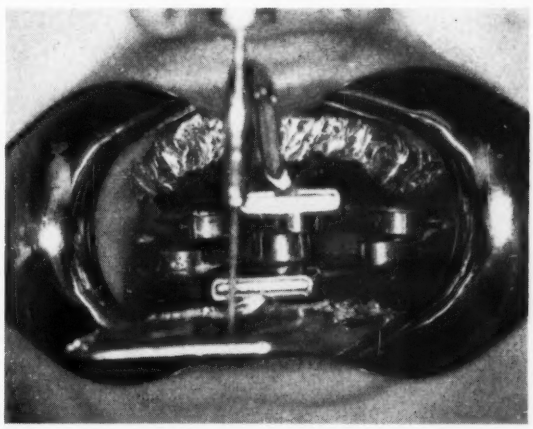

Fig. 6.—The Stansbery extraoral tracing device.

EVALUATING TRIPOD

This instrument was similar to a Hooper duplicator in that it consisted of an upper tripod and a lower base (Fig. 7). It was modified to facilitate the accurate recording of changes that took place during the various registrations. A Hanau-type mounting ring was attached to the center of the upper tripod. This mounting ring could be moved up and down by means of a center bolt, so that one full revolution of the bolt would raise or lower the ring 1.0 mm. The three legs of the tripod were tipped with tool steel and could be moved up and down separately.

The amount of movement could be measured as the distance between the locking and adjusting screw. The base of the instrument had a mounting table in the center. Three arms projected from this mounting table, and squares of steel

were fixed at their extremities. These were graded into 1.0 mm. squares. The exact center was pitted, and the pointed ends of the upper tripod fitted exactly into the center of each grid (Fig. 8).

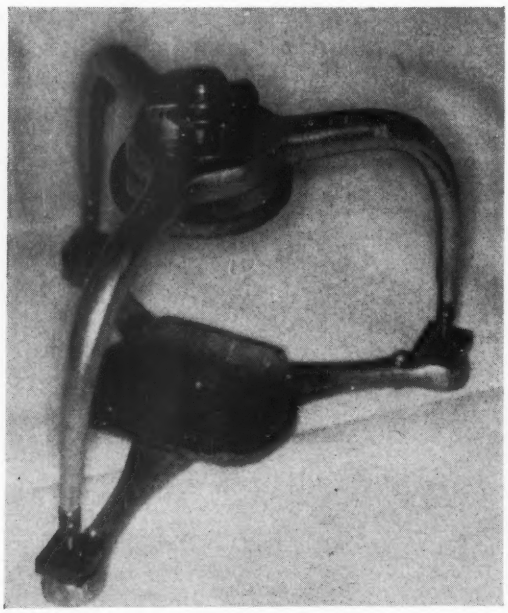

Fig. 7.—The recording instrument.

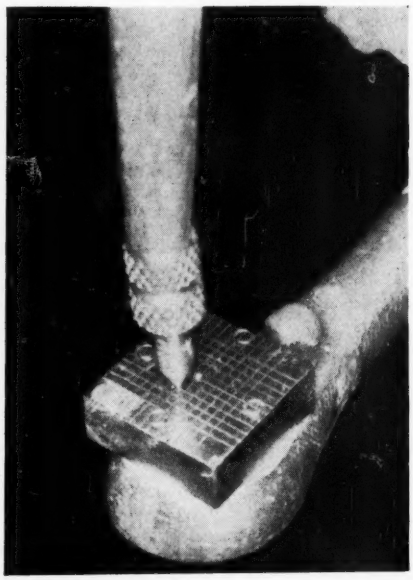

Fig. 8.—Detail of the recording grid.

RECORDS

The variations observed during the various procedures were recorded on millimeter graph paper. Separate recordings were made of each leg of the tripod. Each millimeter of deviation on the instrument was recorded as a 5 mm. deviation on the recording graph paper in order to facilitate interpretation. Three determinations were accomplished for each type of registration for each patient. Any increase or decrease in vertical height was noted by adjustments in the top screw, and any registration that resulted in the tilting of the instrument, so that one or more legs did not touch the graded square, was recorded with a machinist's filler gauge placed between the tripod and the grid.

The initial mounting was accomplished using the intraoral tracing method as previously described. First, the lower cast was carefully centered on a mounting platform on the base of the instrument. The intraoral registration was then placed in a position on the lower cast. The upper cast was carefully seated into its corresponding occlusion rim, and the upper tripod part of the instrument was placed on the base of the instrument so that the three pointed legs of the tripod rested in the center of the corresponding grids. The upper cast was attached to the upper tripod with a soft mixture of plaster of Paris. All three of the registration devices, that is, the intraoral, the extraoral, and the wax rims, were carefully

checked on the tripod to ascertain that no discrepancies existed at the initial reading. The stabilized baseplates, with the various types of recording aids, were then carried to the patient's mouth and centric registrations were made as described previously. The lower stabilized baseplates were carefully fitted onto the casts, and the upper cast was seated into the upper stabilized occlusion rim. When the cast was seated in the proper position, the position of the three pointed legs of the tripod in relation to their central pits were plotted on the recording data sheets (Fig. 9). If any of the three legs did not touch their respective grids, the distance between the grid and the pointed end of the leg was determined with a filler gauge and recorded.

Fig. 9.—An assembled registration ready for evaluation.

The randomization of presentation of the various methods was imperative in that fatigue or learning might have played a part in the relative accuracy of the recording procedures. It was felt that another variable was intraoperator consistency and interoperator consistency. The intraoperator consistency was the amount of variability in the recording of a centric relation by a certain method on the same patient by the same operator during a series of determinations. Interoperator consistency was the amount of variability in the recording of centric relation of the same patient by different operators during a series of determinations. The recordings on all 31 patients were accomplished by one operator. Ten of these patients were further evaluated utilizing 10 different operators; the first 5 used all 3 methods of recording procedures in triplicate, and the last 5 only 2 methods (wax and intraoral) in triplicate.

In order to find the deviation of each record from a central point, a geometric projection was accomplished which resulted in a central deviation for each registration.

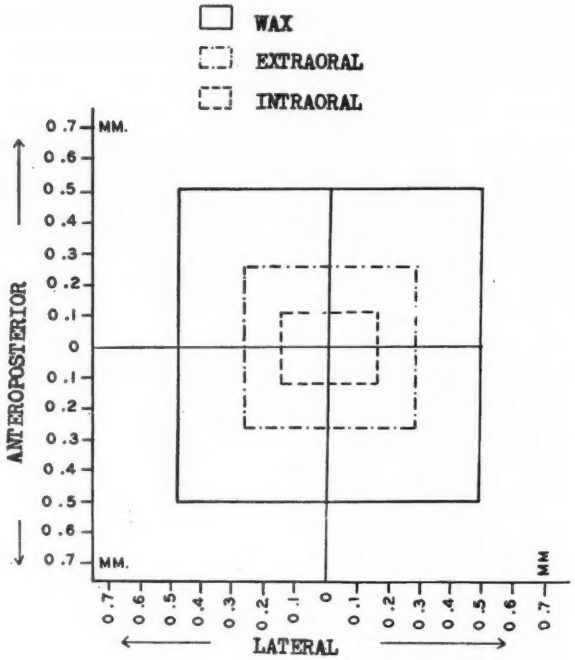

Fig. 10.—Diagram of the magnitude of deviation from the central tendency of the various methods of registration.

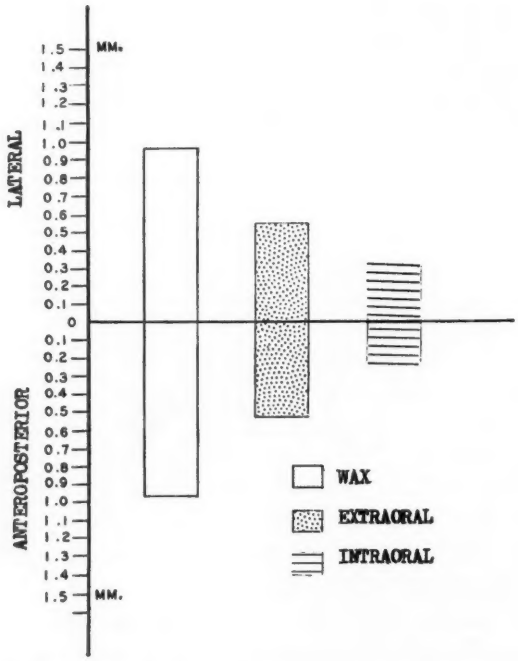

Fig. 11.—Scatter of the various types of registrations.

The mean central deviation for each patient was calculated for each method. The scatter of the individual determinations is presented as the difference between the mean central deviation and the individual deviations. This was done in order to avoid prejudice in favor of the intraoral method, since all cases were initially mounted by this method. Thus, all comparisons are presented as the variation from their central tendency. It is logical to compare one method to another using this type of analysis. In order to demonstrate the reliability of registrations with different methods, measures of dispersion were computed for each method. These calculations indicated the scatter or spread of the registrations around a central tendency for each method. The method which had a relatively large variation would be less reliable. Standard deviations in millimeters were computed for the 3 different methods and are presented in Table III.

TABLE III. STANDARD DEVIATIONS

	WAX		EXTRAORAL		INTRAORAL	
	X AXIS	Y AXIS	X AXIS	Y AXIS	X AXIS	Y AXIS
Interrecording results	0.47	0.50	0.27	0.26	0.15	0.11
First 5 cases with flat ridges	0.37	0.59	0.11	0.19	0.12	0.10
Last 5 cases with flat ridges	0.75	0.40	0.21	0.33	0	0
Well-developed ridges	0.42	0.55	0.30	0.25	0.04	0.04
Flat ridges	0.56	0.51	0.16	0.26	0.08	0.06
Flabby ridges	0.33	0.40	0.44	0.29	0.34	0.22

Fig. 10 is a diagrammatic presentation of the standard deviation of the scatter of the various registrations. In this experiment it was noted that the wax registration had 3 to 4 times the deviation of the intraoral method but that the deviations amount to fractions of a millimeter, and for the most part would be hardly discernible clinically. Fig. 11 is a modified bar graph illustrating the scatter of the registrations. This is plotted as 2 times the standard deviation, and statistically, 95 per cent of all registrations would fall within these limits. It is apparent that the wax method showed more scatter as compared to the extraoral tracing procedures and the intraoral tracing procedures.

STATISTICAL EVALUATION

A statistical evaluation was accomplished to determine if these differences were significant. Critical ratios were computed. A critical ratio of 2.56 indicated a difference significant to the 1 per cent level. The critical ratio found between wax and intraoral was 4.77 (1 per cent significance), wax versus extraoral 4.34 (1 per cent significance), intraoral versus extraoral 0.84 (not significant). It was, therefore, apparent that the difference in scatter between the wax method and the graphic tracing procedures was significant above the 1 per cent level. The amount of scatter between the extra- and intraoral tracing procedures was not significant.

Calculations indicated that the reading error of an individual operator (the ability of the operator to duplicate readings on identical checkbites) was not significant. It was less than 1/10 the standard deviation for each method.

The influence of experience on the part of the operator on the over-all results was calculated. The first 5 cases with flat ridges were compared to the last 5 cases with flat ridges. The results are presented in Table III. The critical ratios were as follows: wax method 2.18 (5 per cent significance), intraoral method 0.22 (not significant), extraoral method 1.69 (not significant).

In order to determine whether the results were consistent when handled by a series of operators, the standard deviations between intraoperators and interoperators were computed for each method on the same 5 cases. Five other operators used only the intraoral graphic and wax registrations. Table III gives the results of these calculations. Slight differences were apparent in all three methods. Critical ratios were found to be wax method 0.46 (not significant), intraoral method 0.20 (not significant), and the extraoral method 0.59 (not significant). It was also found that the pattern of deviation for the intra- and interoperator consistencies for the 3 methods studied were similar, in that the wax registration method showed the largest variation.

TYPE OF RIDGES

The influence of the type of ridges on the results was evaluated. These are presented in Fig. 12. It was found that the wax method showed the least amount of scatter in patients with flabby ridges and the widest scatter in patients with flat ridges. The intraoral and the extraoral tracing procedures showed maximum variability in patients with flabby ridges and minimum variability in patients with good ridges. Further analysis indicated that the general pattern of scatter in the three different methods remained the same in the 3 groups with different types of ridges. This pattern corresponded with the pattern representing the scatter of different methods in the over-all analysis. The wax method showed the maximum variability, and the intraoral tracing procedure showed the minimum variability.

An evaluation of these findings indicated that the difference of scatter in the extraoral method with different types of ridges was not statistically significant. The wax method had a significant variation in patients with flat and good ridges as compared to those with flabby ridges. This was demonstrated by the critical ratios of 3.33 and 4.37. No significant differences in scatter were indicated for this method in patients with flat and good ridges. The critical ratio between flabby and flat ridges was 3.46, and between flabby and good ridges was 3.53 for the intraoral tracing procedures. This represents a significant difference in the scatter using the intraoral method in patients with flabby ridges as compared to patients with flat and good ridges. The critical ratio of 0.78 between flat and good ridges indicated no significant variation. It was also noted that in patients with good ridges the wax method showed a significant variation from the other two methods. No significant difference in scatter was shown between the intraoral and extraoral tracing procedures. The same results were true for patients with flat ridges. In patients with flabby ridges, the three methods showed no significant variation between each other.

VERTICAL DISCREPANCIES

The factor of vertical discrepancies was considered in this study. Swenson[53] has called this dimension "equalized vertical contact." Hanau referred to it as "Realeff,"[12] Trapozzano,[2] as equalization of pressures. Boswell[34] has described the possibility of vertical change independent of true vertical dimension. This has been called the "Boswell movement."

It was difficult to measure accurately any changes in equalized vertical contact[34] on the previously described instrument. Therefore, the magnitude of deviation recorded at one or more poles of the instrument was not given statistical treatment. Instead, an evaluation was made to determine the percentage of records that showed vertical discrepancies at one or more poles of the instrument (Fig. 13). Nine per cent of the records obtained by using the intraoral graphic device showed vertical discrepancies, 18 per cent showed these changes in the wax method, and 24.5 in the extraoral method.

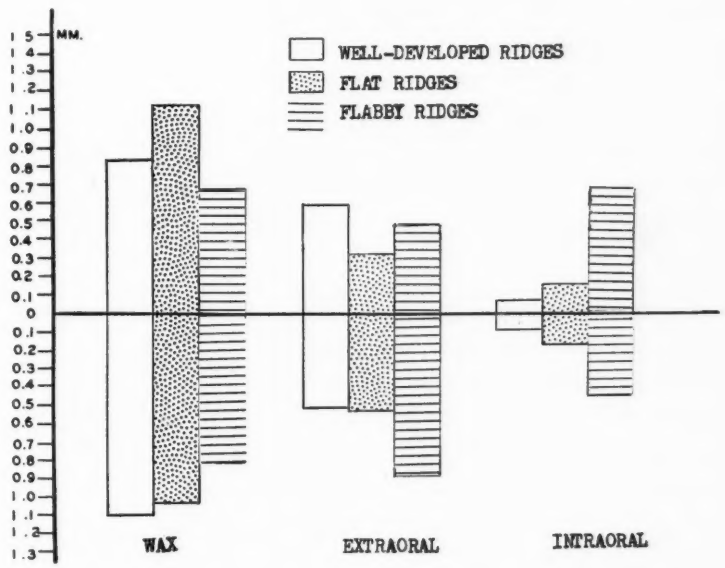

Fig. 12.—Comparison of results obtained with various ridge classifications.

DISCUSSION

An over-all evaluation of the results indicated that the intraoral tracing procedure was the most consistent of the 3 methods studied. No significant statistical difference could be shown between the intra- and extraoral tracing procedures. The magnitude of difference in consistency between the graphic tracing procedures and the wax method was demonstrated to be statistically significant. From the analysis of the intra- and interoperator recordings, it was shown that the results obtained in this experiment could be duplicated by 10 other operators.

In considering the influence of different types of ridges on the consistency of the various methods, it was found that the intraoral tracing procedure was again

the most consistent in the patients studied. The wax method seemed to be the least consistent. There was no statistical difference between intra- and extraoral tracing procedures in all 3 types of ridges studied. The difference between the intraoral tracing procedure and the wax method in flat and good ridges was statistically significant. However, this difference was not significant in patients with flabby ridges. This indicated that the consistency of the intraoral tracing procedure decreased greatly in patients with flabby ridges. This decrease of consistency was demonstrated to be statistically significant. Extraoral tracing procedures also followed this same pattern. However, no statistical significance could be demonstrated.

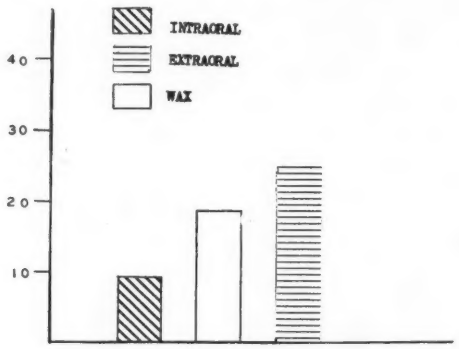

Fig. 13.—Percentage of registrations showing vertical discrepancies.

The wax method became more consistent in patients with flabby ridges as compared to its consistency in other types of ridges. It was shown that the magnitude of variation remained approximately the same regardless of the type of ridge studied in the wax registration method. This tended to substantiate Trapozzano's statement to the effect that a wax registration procedure is an accurate method but that it requires experience to maintain this accuracy consistently.[2] It is also in agreement with the general observation that in inexperienced hands, the graphic tracing procedures seem to prove more reliable. It must be noted that the improvement in consistency of the wax method in patients with flabby ridges may have been influenced by the fact that all 5 patients studied in this group had denture experience ranging from 12 to 25 years. The lack of consistency of the graphic tracing procedures in flabby type ridges indicated that the mucosal resiliency did affect the consistency of results. This confirms the findings of Trapozzano and Kingery in that "the use of the central bearing point will produce equalization of pressure only if mucosal resiliency is extremely slight."

CLINICAL OBSERVATIONS

It was observed that there was little difference in time required to accomplish any of the registration procedures studied. In cases with limited maxillomandibular space, the extraoral device could not be accommodated. The extraoral procedure seemed a little more difficult for senile type patients, in that it was difficult

for them to hold steady for the two to three minutes required for the plaster keys to set. In the case of the intraoral tracing procedure, the use of a disk to hold the tracer in position while the plaster was setting was accomplished with more facility by the patient, and yet, at the same time, it must be pointed out that lateral force may be exerted by this procedure due to the locking effect.

SUMMARY AND CONCLUSION

A study was conducted in order to evaluate the commonly used methods of recording centric relation in complete denture prosthesis. Thirty-one patients were selected from the Tufts University School of Dental Medicine, Prosthetic Clinic. The following 3 methods were selected for the purpose of the experiment: (1) extraoral tracing procedure (after Stansbery), (2) intraoral tracing procedure (after Hardy), and (3) wax registration procedure (after Hanau). Three interocclusal records were made by each method for each patient. It was found that the intraoral tracing procedure and the extraoral tracing procedure were more consistent as compared to the wax registration method. In patients with flabby ridges, the intraoral tracing procedure and extraoral tracing procedure became less consistent as compared to their consistencies in patients with good and flat ridges. The consistency of the extraoral tracing procedure did not vary significantly in patients with different types of ridges. The degree of consistency of the intraoral tracing procedure decreased to a significant level in patients with flabby ridges.

The wax method seemed less consistent than the extra- and intraoral tracing procedures. It showed the least consistency on flat ridges and the highest consistency in the flabby ridge groups. The differences in consistency between the intraoral tracing procedure and the extraoral tracing procedure was not statistically significant. It must be noted that the mean deviation in millimeters of all 3 methods approached $\frac{1}{5}$ to $\frac{2}{5}$ mm. This amount in the case of an edentulous patient is barely perceptible clinically.

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TERMINAL HINGE MOVEMENT OF THE MANDIBLE

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IT HAS BEEN SHOWN THAT the human mandible can carry out an opening movement to a distance of up to 20 mm. between the incisors while both condyles remain in their most posterior positions.[12] This movement is known as the terminal hinge opening and closure.

Unlike the simple relaxed opening and closing of the mouth, the terminal hinge movement is remarkably constant,[12] and although it is most readily produced passively, it can, with a certain amount of practice, also be reproduced actively.[12]

Some authors[1,4,5,9] have recorded a stationary axis of the hinge movement which they consider of great practical importance for maxillomandibular relation registration.[12] The projections of the kinematic axis points on each side of the face are called the axis points.

It should be stressed that the terminal hinge movement is a type of movement which *can* be performed, but it does not, even in its initial phases, coincide with the simple relaxed "natural" opening or closure. The latter movements are, kinematically, more complicated.[7,10,12]

RELATION OF HINGE AXIS TO CONDYLES

McCollum,[9] using cassettes in the sagittal plane on two cadavers, observed by roentgenograms that the axis points fell within the outlines of either condyle.

Beyron[1] studied 10 subjects in whom the axis points on either side were marked with metal indicators. Tomograms were made in the most posterior closed position and on a terminal hinge opening of 10 mm. Good[6] used profile roentgenograms for a similar investigation on five dentulous individuals. Beyron[1] and Good[6] found that the axis point of each condyle was located within the outline of the condyle but not in any regular relationship to any definite part of the latter.

AIM OF THE PRESENT INVESTIGATION

This study was undertaken to further elucidate the terminal hinge movement up to 20 mm. of hinge opening by checking the relation of the axis points to the condyles and by recording the shift of the kinematically established hinge axis.

MATERIAL AND METHODS

Profile roentgenograms were made of 19 male volunteers (undergraduates) aged 20 to 29 years, and with all or nearly all of their teeth present.[12] Roent-

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genograms were made of the mandible in (1) the most posterior contact position, (2) the most posterior position with a hinge opening of about 20 mm., and (3) with maximal opening. Position 2 was fixed after making a graphic registration by means of a method previously described.[12]

For registration with the Gnatho-thesiometer,[13] a further 13 subjects were used, satisfying the same requirements as to their teeth.

TRACING OF THE PROFILE ROENTGENOGRAMS

The roentgenographic outline of the most important parts of the skull, with the mandible in the most posterior contact position, was traced onto transparent paper. Tracing the outline of the mandible was attended by the following difficulties: (1) The upper outline of the condyles is, as a rule, discernible only when

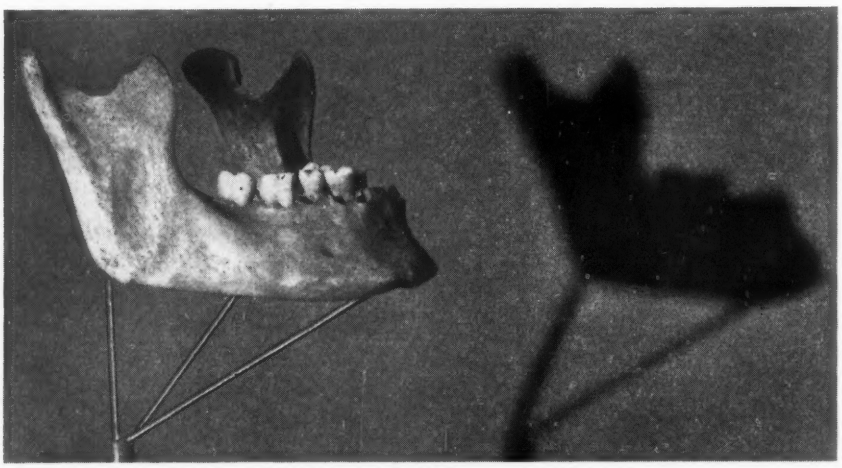


Fig. 1.—A mandible on a rotatable frame for checking tracings of profile roentgenograms. The entire apparatus is shown in Fig. 2.

the mouth is fairly wide open, or in the protruded position. It was usual to trace the entire outline of the mandible with the mouth wide open and to transfer it to the position of the mandible with the mouth closed. This could be done accurately because the outline of the entire mandible, except the condyles, was distinct in both roentgenograms. (2) Fairly often, double contours occurred, especially in the region of the ramus. As the roentgen rays are not exactly parallel, the distance between the contours varied with the distance between the rami and with any asymmetric position of the jaw. The latter difficulty was eliminated by drawing an intermediate line between the double contours.

The accuracy of the measurements of parts capable of giving double contours has been analyzed by Björk.[2] He found that reference points intermediate between double contours gave the least error in measurement. According to Björk, the standard deviation on roentgen measurements from the point 'articulare'[12] to other reference points is between 0.3 and 0.8 mm. Whereby, it should be observed that these errors appear as a summation of the marking of two points, i.e., one point in addition to the 'articulare' point. As far as the contour of the

angle of the mandible is concerned, the mid-point was likewise found to be much more accurate than either contour point.

Judging from these results, the mandibular outlines of particular interest, namely, those of the condyles, ramus, and mandibular base, can be traced with such a high degree of accuracy that a forward-downward gliding of the condyles, for example, and small deviations of such a shift can be judged with satisfactory accuracy.[12]

In order further to assess the accuracy of the tracing method, the following experiments were carried out:

A mandible was mounted in a graduated frame which permitted rotation around a vertical axle and around a sagittal axle (Fig. 1). The vertical axle was approximately 1 cm. behind the intercondylar axis. The occlusal plane was horizontal. A light was projected on the mandible, and it produced a shadow (Fig. 1). The sagittal axle crossed the vertical axle 14 cm. below the mandibular base as shown on the shadow.

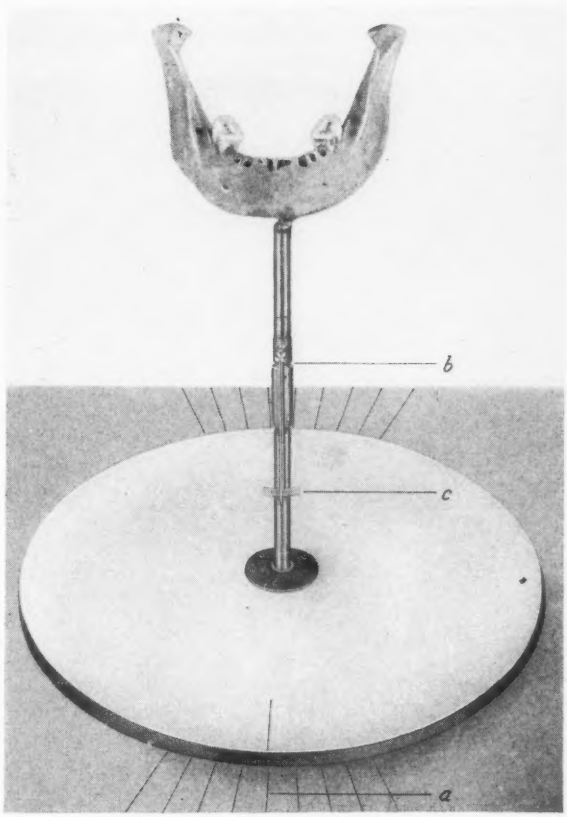


Fig. 2.—The apparatus for checking tracings from roentgenograms. The degree of rotation around the vertical axle can be read from the scale (a) on the base. Rotation around the sagittal axle (b) can be read from the frontal scale at (c).

The sites of these axles and the shape of the frame were arbitrary and do not indicate the author's concept of mandibular kinematics. Only the terminal hinge movement is dealt with here.

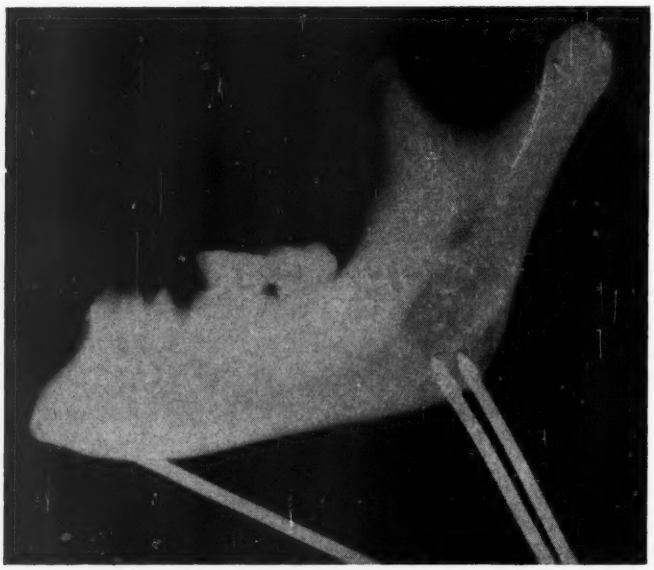


Fig. 3.—A roentgenogram of the mandible in an unrotated position.

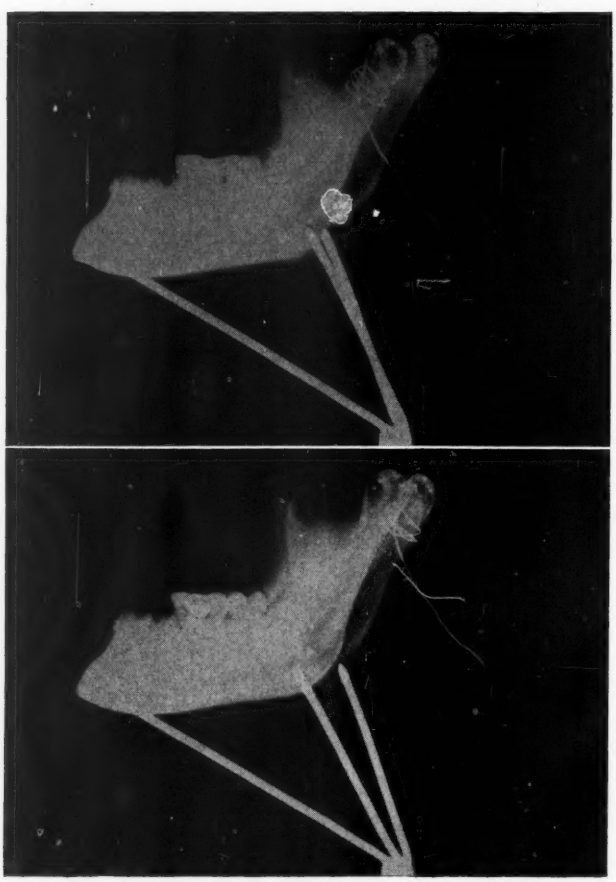


Fig. 4.—Roentgenograms of the mandible. *Above,* At 5 degrees left rotation around the vertical axis. *Below,* In right rotation.

The experimental apparatus was arranged so that the central ray passed through both condyles (Fig. 2). Profile roentgenograms were made, first without rotation, then with 2.5 degree and 5 degree rotation around the vertical axle, and finally around the sagittal axle. The degree of rotation around the vertical axle was read from the scale on the base of the apparatus (Fig. 2). Rotation around the sagittal axle was read from the frontal scale (Fig. 2).

Tracings were made of the roentgenograms of the model in unrotated (Fig. 3) and in rotated (Fig. 4) positions, the outlines of both sides, as well as the mid-outline being traced (Fig. 5). The tracing of the unrotated model fitted exactly into the mid-outline both at 2.5 degrees and 5 degrees rotation in either direction. Rotation of 5 degrees around a vertical axle resulted in a maximum distance of 12 mm. between the previously determined points in the region of the angle of the mandible. This is more than was ever seen in roentgenograms of mandibular positions which, theoretically, should be symmetric, such as the most posterior contact position, the occlusal (intercuspal) position, and the anteroposterior contact positions.

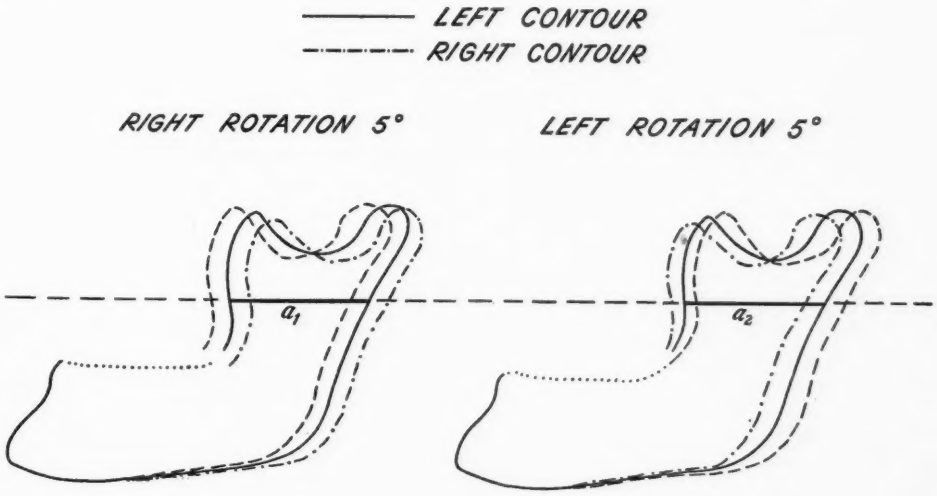
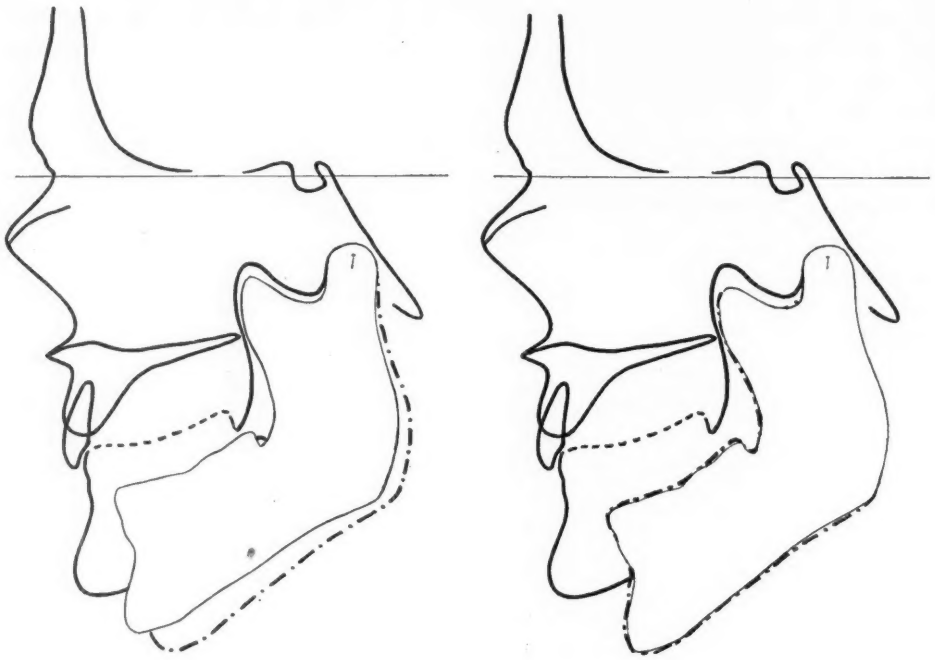


Fig. 5.—Tracings of the two profile roentgenograms shown in Fig. 4. It is difficult to show in the reproduction that the tracing of the roentgenogram in Fig. 3 coincides exactly with the mean outline. Two parts, a_1 and a_2 of a horizontal line through the ramus were found to be the same length in each tracing.

REPRODUCTION OF THE TERMINAL HINGE MOVEMENT WITH A CARDBOARD PATTERN

If the mandible rotates around a frontal axis passing through both condyles, any given point on the mandible must rotate concentrically around the axis. This was checked by the following experiment. Cardboard patterns were made from roentgen tracings of the jaw with the mouth wide open. By means of concentric circles[7] marked on celluloid and placed 1.0 mm. apart, the approximate center of the upper and lower contours of the condyles on the tracings was determined.

The center point was transferred to the cardboard pattern, which was then placed so as to coincide with the contour of the mandible in the most posterior contact position. By rotation of the cardboard model around a pivot at the site of the center thus located, the contours of the cardboard should coincide with the contours of the mandible traced from the roentgenogram of the jaw in the retruded open position registered. This was found to be so (Fig. 6).



A. *B.*

Fig. 6.—The experiment with rotation of a cardboard pattern around the hinge axis which was located. *A* shows rotation in part. *B* shows complete rotation of the cardboard pattern. The . — . — . — line corresponds to a terminal hinge opening of about 20 mm.

GEOMETRICAL CONSTRUCTION OF THE HINGE AXIS FROM PROFILE ROENTGENOGRAMS

Roentgenograms were made with the mandible in passively held positions[12] (Fig. 10). The outlines of the skull and mandible were then traced on paper.

According to the above line of thought, on rotation around a stationary intercondylar axis, a point on the anterior part of the mandible and a point on the mandibular base should move concentrically around the hinge axis. If the positions of the two points on the mandible are connected by a straight line, they will form a cord to the concentric paths of the two points. As a point on the anterior part of the mandible, an indicator point was selected as shown previously.[12] As a point on the mandibular base, a point can be marked, e.g., on the angle, which is then transferred to the film of the mandible with the mouth open by allowing only

the contours of the lower jaw to coincide in these films. However, it is probably easier to mark the point of intersection on the mandibular base with a compass.

If mid-point perpendiculars are drawn to the chords, their extension must meet the axis of movement, and then they must bisect one another at the point denoting the hinge axis. In Fig. 7, the mid-point perpendiculars have been drawn to the chords, but only the end-points of which are marked.

It should be observed that any error in the marking of the points, and in the construction or drawing of the lines, increases with the distance between the axis and the pair of points.

This construction was made for 17 subjects (Fig. 9).

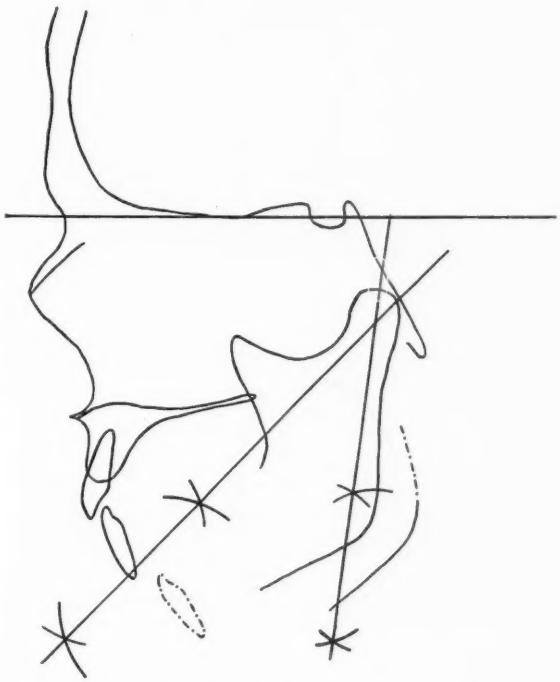


Fig. 7.—The geometric construction of the axis of the terminal hinge movement.

AXIS POINTS RECORDED BY MEANS OF A KINEMATIC FACE-BOW AND CHECKED BY PROFILE ROENTGENOGRAMS

In 4 subjects, the axis points, as found by means of a kinematic face-bow registration, were marked on each side with metal indicators. Profile roentgenograms were made in the most posterior contact position and in the most posterior open position.[12]

HINGE AXIS ESTABLISHED BY MEANS OF KINEMATIC FACE-BOW AND CHECKED BY MEASUREMENTS IN THE GNATHO-THESIOMETER

Duplicate Gnatho-thesiometric[13] measurements were made of 13 persons in whom the axis points had been determined by means of a kinematic face-bow.

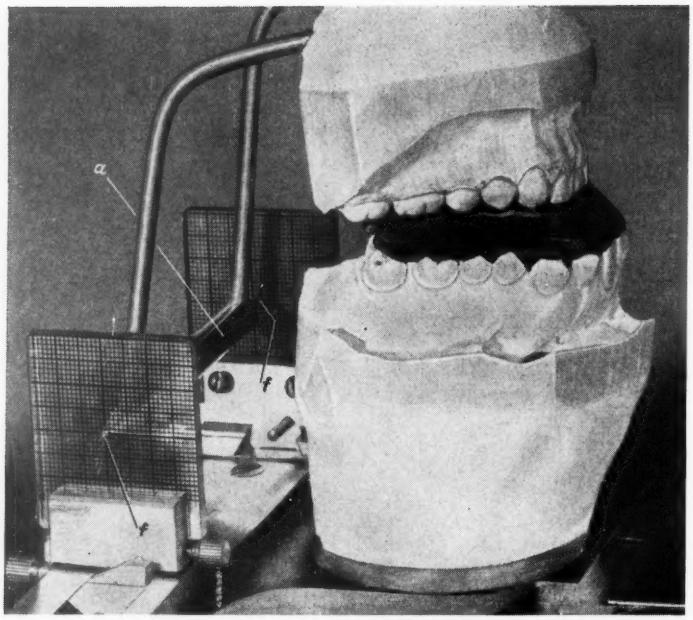


Fig. 8.—The mandibular cast was mounted on the Gnatho-thesiometer in the most posterior contact position. The 15 mm. thick hinge record has been interposed between the occlusal surfaces and the shaft unlocked from the holes (f) of the measuring plate. Only very slight shift of the shaft (a) from its zero position is observed.

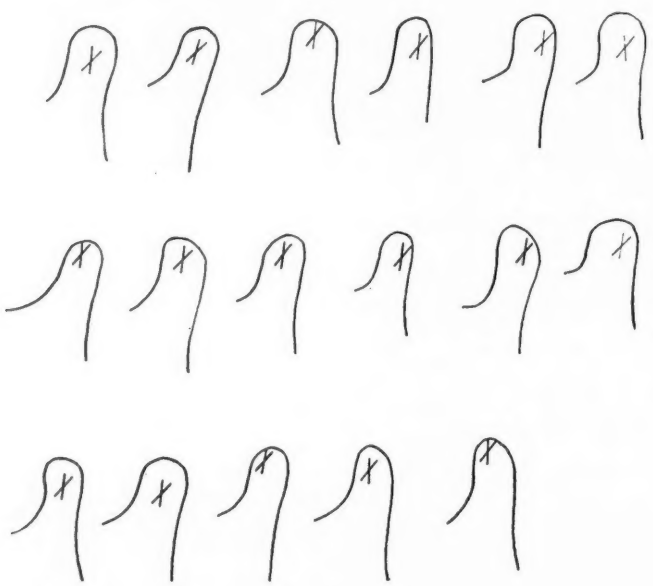


Fig. 9.—Constructed median section of terminal hinge axes of 17 subjects.

Positions on the terminal hinge movement were analyzed by means of thick wax records with degrees of hinge opening of approximately 5, 10, and 15 mm. (See average openings in Table I.) Deviations from the zero positions of the shaft points in the sagittal planes were read on both sides (Fig. 8).

Two subjects were examined by all three methods.

Fig. 10.—Profile roentgenograms with an opening of about 20 mm. The mandible is in the terminal hinge relation. Metal indicators, as seen in the contours of the condyles, have been fastened to the skin at the axis points.

RESULTS

1. Fig. 9 shows the axes constructed from profile roentgenograms in relation to the common contours of the condyles. It was found that the median section of the terminal hinge axis lay within the outlines of the condyles throughout, although, in some cases, they were near the actual outline.

2. A position slightly anterior to the mid-point of the condyles was recorded for 2 of the 4 cases in which metal indicators had been attached to the axis points on either side of each subject (Fig. 10).

3. The standard deviations for sagittal shifts from the kinematically established hinge axis appear in Table I.

Three different experimental methods—none, of course, without error—gave fairly similar results. This suggests that the terminal hinge movement with a

TABLE I

AVERAGE HINGE OPENING IN MM.	STANDARD DEVIATIONS FOR RIGHT AND LEFT SHAFT POINTS TAKEN TOGETHER	
	ANTERIOR-POSTERIOR	INFERIOR-SUPERIOR
4.5	0.6	0.8
10.0	0.7	1.0
16.0	1.1	1.3

recorded extension of 15 to 20 mm. can be regarded as rotation around an axis passing through the condyles.

DISCUSSION

The hinge opening, as measured on the roentgenograms,[12] corresponds to an angle of 15 degrees on the average (range: 12 to 18 degrees). Therefore, the distance, for instance, between the two positions of the point on the mandibular base in the open and closed positions is relatively small. This makes the determination of perpendiculars less reliable.

Although the experiments presented here suggest that the mandible carries out its terminal hinge movement around an axis passing through the condyles, they do not per se imply that the axis can be precisely recorded by means of a kinematic hinge axis face-bow,[3,8] nor do they elucidate problems concerning the imitation on an instrument[11] of the terminal hinge movement.

SUMMARY

The terminal hinge movement was analyzed by means of the following methods: (1) geometric construction from profile roentgenograms; (2) axis points recorded by means of kinematic face-bow and checked by profile roentgenograms; and (3) hinge axis established by means of kinematic face-bow and checked by Gnatho-thesiometric measurements.

The results obtained were similar in so far as they showed the axis of the terminal hinge movement to pass through both condyles or make only minor shifts. This is true for hinge openings of 15 up to 20 mm.

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MUCOSAL INSERTS—A PROGRESS REPORT

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THE UPPER DENTURE PRESENTS less difficulty to the average prosthodontist than does the lower denture in most instances. However, there are some patients who have more difficulty with upper dentures, even though the impressions, extension, relief, occlusal harmony, vertical dimension, centric relation, and other factors have been properly respected and worked out in the fabrication of the dentures. There are some patients who cannot accommodate to the usual complete dentures. The patients in this category are: (1) those who reject the upper denture psychologically, and complain of gagging, mobility, impediment of speech, improper esthetics, etc.; (2) those who have unfavorable anatomic conditions, such as excessively resorbed maxillae with flat ridges, and particularly those with excessive resorption in the anterior region (these patients complain of a forward displacement of the denture base when the teeth are in occlusion and have a constant need for adjustment and relief of the anterior border and base of the denture); and (3) those who manifest excessive protuberances of bone in the anterior region which preclude the possibility of an esthetic restoration of the anterior aspect of the prosthesis.

These are the patients that tax the skill of the prosthodontist and justify more radical efforts for alleviating their difficulties.

In a previous report,[1] a technique for placing mucosal inserts on the tissue surface of a denture was described. The inserts were located in arbitrary positions over the crest of the ridge and in areas where the mucosa was sufficiently thick to accommodate them (Fig. 1). Time has shown that tissue-tolerated materials, such as Vitallium, can be used as mucosal inserts. Since the first report,[1] mucosal inserts of many different sizes have been used in many different positions (Fig. 1). The optimal insert has the following dimensions: diameter, 2.5 mm.; thickness, 1.0 mm.; and length of the stem, 1.5 mm., with a split circular base 3 mm. in diameter and 1.5 mm. in thickness.

The best results have been obtained by positioning four mucosal inserts over the crest of the ridge on each side. These are placed in the region of the lateral incisor, cuspid, first molar, and second molar teeth. Also, two inserts are placed on the lingual side of the ridge, midway between the ridge inserts, and anterior to the greater palatine foramina.

ATTACHING THE INSERTS

The denture to which the mucosal inserts are to be attached must be correct in its basic form and adaptation. The insert can be attached to an existing denture, provided the occlusal balance, vertical dimension, adaptation, and border extension are correct.

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The entire palate, vestibule, and ridge are carefully surveyed to determine the thickness of the soft tissues and to locate areas suitable for the insertion of the mucosal inserts. The selected sites are marked with an indelible pencil (Fig. 2). Usually twelve such sites are selected. The denture to be modified is inserted in the mouth under mild pressure. When the denture is removed (Fig. 3), the indelible pencil markings will be transferred to the tissue surface of the denture base. Using a large inverted cone bur, or a specially designed bur of the same

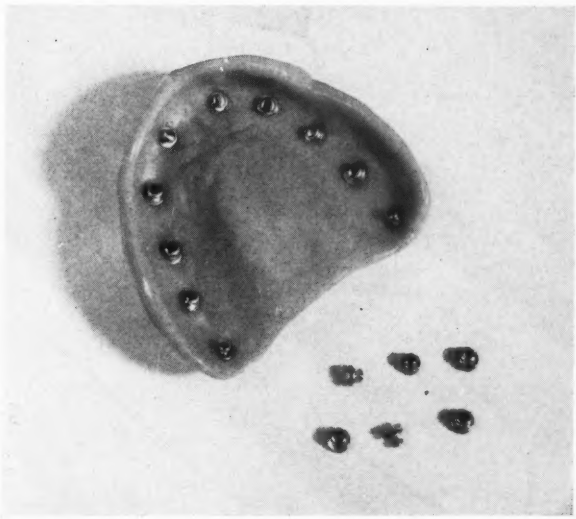

Fig. 1.—The original simple upper mucosal inserts. Note that the inserts are of varied size and are positioned arbitrarily in the crest of the ridge.

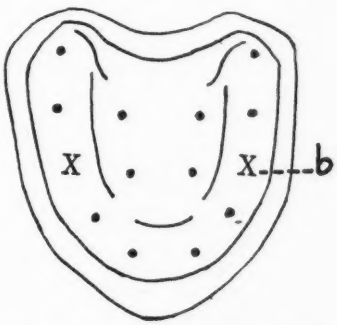

Fig. 2.—Diagrammatic illustration of areas on the palate and ridge that are usually desirable for mucosal inserts. *b*, Diagrammatic illustration of cross incision for insert. (From Lew, Isaih, and Kestenbaum, Irving: Implant Button Technique of Denture Prosthesis, Dental Digest, July, 1953.)

size as the base of the mucosal insert (approximately 3.5 mm. in diameter), a circular hole of about 3.5 to 4.0 mm. in diameter is cut in the impression surface of the denture base to a depth of approximately 2.0 mm. The base of the mucosal insert is fitted into the prepared hole. The hole should be larger than the base of the insert and deep enough to allow the base of the insert to be continuous with the denture surface. Autopolymerizing acrylic resin is used to secure the mucosal

inserts to the denture base. Particular care must be used to remove any excess acrylic resin from around the necks of the inserts, and from the periphery of their bases. The attaching resin is highly polished.

PREPARATION OF THE SOFT TISSUE

The heads of the inserts are marked with indelible pencil and the denture is placed in the mouth under moderate pressure (Fig. 4). When the denture is re-

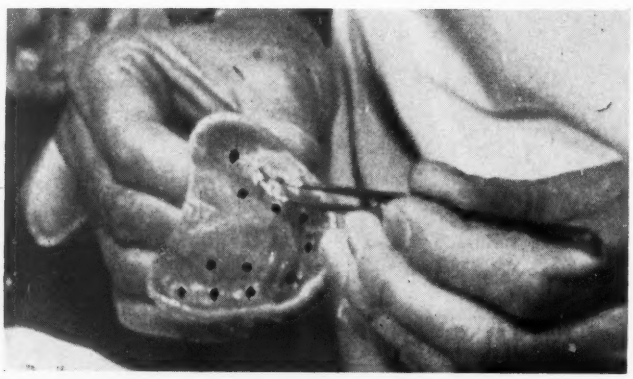

Fig. 3.—A denture with markings duplicated from those in the mouth of the patient. An insert is tried into the prepared opening on the undersurface of the denture base. (From Lew, Isaih, and Kestenbaum, Irving: Implant Button Technique of Denture Prosthesis, Dental Digest, July, 1953.)

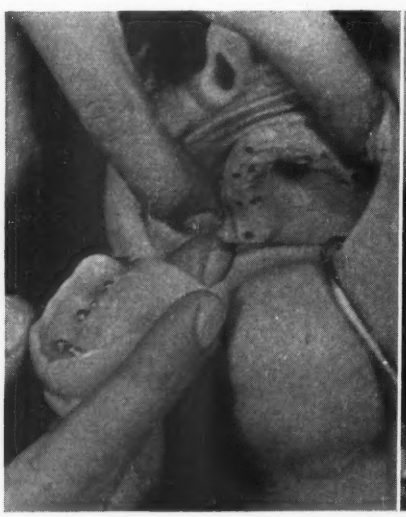

Fig. 4.

Fig. 5.

Fig. 6.

Fig. 4.—The finished denture, with the inserts attached, marked with indelible pencil, and inserted in the mouth. The markings are duplicated in the mucosa by the insertion of the denture.

Fig. 5.—Several drops of anesthetic are introduced into each marked area.

Fig. 6.—A cross incision is made at each marking.

moved, the marks will have been transferred to the mucous membrane, and the pressure will have caused the indentation of the tissue by the heads of the mucosal

inserts. Several drops of a local anesthetic are injected into each marked indentation (Fig. 5). Cross incisions all the way to the bone are made with a Bard Parker No. 15 scalpel at the site of each insert (Fig. 6). The incisions are 6 to 8 mm. long each way with the previously made indentations and indelible marks serving as center guides. When the soft tissue thickness, as measured by an explorer, is too shallow to accommodate the entire length of the insert, a No. 4 round bur is used to create the required space within the bone.

The anesthetic will limit the hemorrhage which will occur only when the molar palatal insert incision is made too near the posterior palatal blood supply. In such instances, the application of moderate pressure for several minutes will arrest the flow of blood and allow the insertion of the appliance.

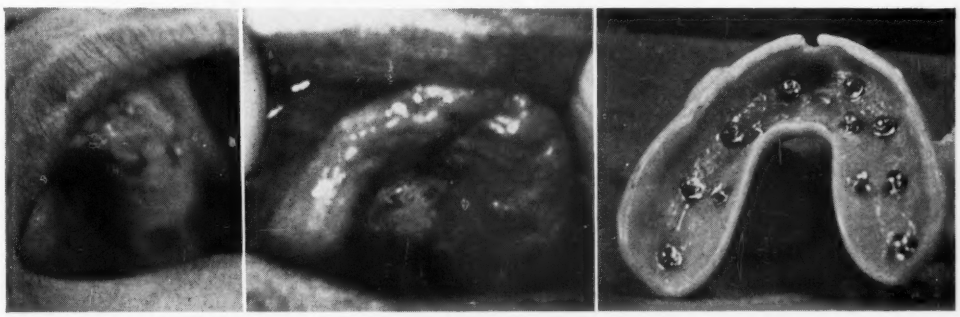

Fig. 7. Fig. 8. Fig. 9.

Fig. 7.—Postoperative appearance after one week. The tissues appear red and gelatinous (granulating tissue).

Fig. 8.—The postoperative appearance after four weeks. The tissue opening is hardly visible. Note the absence of the inflammatory process. The openings are hardly larger than the insert posts.

Fig. 9.—A denture with the palate removed. This is applicable where the vault is high and the retention is adequate.

INSERTION OF THE DENTURE

The denture is thoroughly scrubbed and sterilized and is inserted with a jiggling motion to force the mucosal inserts into the soft tissue at the cross incisions. The postpalatal seal will cause a mild blanching when the denture is properly seated. A careful check of occlusion will be a check on the proper seating of the denture. Incomplete seating may be caused by improperly located incisions, or insufficient thickness of the soft tissues. Either of these conditions must be corrected before the patient is dismissed.

POSTINSERTION CARE

The success or failure of this technique depends, primarily, upon patient cooperation. Once the denture with the mucosal inserts is placed in the mouth, the *patient must not remove the appliance for an entire week.* A very small percentage of these patients have any desire to remove the denture. This can be explained by the fact that denture mobility and the make-and-break contact of the postpalatal seal are eliminated by the inserts. Most patients will return within the week following the insertion and report no desire to remove the denture, and very little pain or discomfort. When the denture is removed at the end of the

week, a surprisingly small amount of debris will be found under it. This is due to the stability of the denture base and to the occlusion of the space by the slight edema created by the trauma of the incisions. After the first week, the incised areas will appear red and gelatinous (Fig. 7). The formation of fibrous tissue repair and the development of normal mucosa may take six weeks, so the maximum retention is not achieved until the fourth or fifth week. The patient must be informed and reassured during this healing period.

Fig. 10.

Fig. 11.

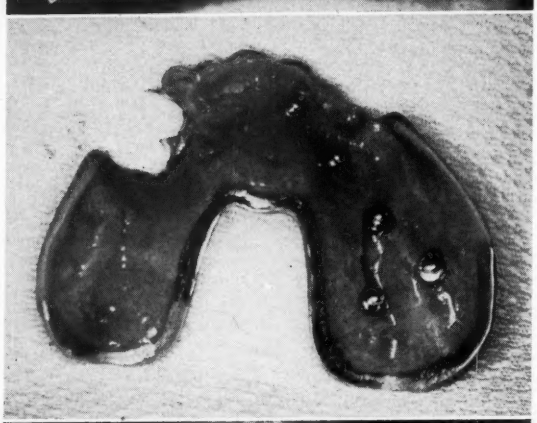

Fig. 12.

Fig. 10.—A difficult upper restoration. Large protruding anterior alveolar ridge. There are two remaining periodontal teeth splinted. Note the absence of the alveolar ridge on the saddle area.

Fig. 11.—A tissue partial prosthesis with simple clasps, and no rests. Note the disposition of inserts for maximum retention.

Fig. 12.—The finished prosthesis. The abutting teeth are natural in appearance. Close adaptation of unsupported saddle. Note the thin upper lip and gross alveolar structure. The labial denture extension creates a difficult esthetic problem. The patient has worn this prosthesis for three years.

After the first week, the patient is allowed to remove the denture every other day. When pain is experienced upon removal, the patient is allowed to remove the denture only two times per week. When the healing is complete, the mucosa should appear almost unbroken, with the openings only visible to careful scrutiny under compressed air (Fig. 8). Careful examination of the mucosal insert opening should show a normal pink color with the opening not much wider than the neck of the mucosal insert

After the healing is complete, and after six weeks of wear has assured adequate retention, the palatal portion of the denture can be removed, provided the vault is sufficiently high (Fig. 9). This must never be done if the vault is flat.

MODIFICATIONS

The mucosal inserts may be used to retain partial dentures in special situations. When the remaining teeth are on only one side of the mouth, the mucosal inserts can be used to retain the partial denture on the edentulous side. The anterior teeth can be butted to the ridge to provide a natural appearance. The mucosal inserts provide stability so little torque or pressure is exerted on the remaining teeth. In such instances, even weak teeth may be left in position (Figs. 10, 11, and 12). The partial denture may be fabricated with mucosal inserts and, when the remaining teeth must be removed, the partial denture can be modified to restore all of the teeth without the construction of a new denture.

LIMITATIONS

Mucosal inserts are not practical in lower dentures because of the relative thinness and sensitivity of the soft tissues covering the mandible.

The author merely reports the gratifying application of this technique and modification employed for patients.

The relative ease, simple surgical technique, inexpensive prosthesis, minimum discomfort, and reparable aspect of the technique lends itself to application for difficult upper prosthesis.

In implant dentures made for lower restoration, the function and stability of the lower denture is increased to such an extent that, by comparison, the patient may complain of the upper denture, which heretofore had served adequately. In these patients, rather than attempt a difficult and extensive upper implant, the mucosal insert has provided sufficient stability to satisfy most implant patients.

We want to bear in mind that this report describes a technique which, properly employed, can help to relieve a difficult prosthetic problem.

The judicious application and selection of patients can never be overemphasized.

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AXIAL INCLINATION AND CUSPAL ARTICULATION IN RELATION TO FORCE DISTRIBUTION

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ONE FACTOR IS FOUND consistently in the recent dental literature on occlusion. It is the desirability of vertical rather than lateral stress to the teeth. Kurth[1] points out that we rarely have true vertical stress on the teeth due to the hinge axis of the mandible and the articulation of the tooth inclines.

It is the purpose of this article to show some of the physiologic forces distributed to the periodontal support in relation to the axial inclination and articulation of the teeth.

MANDIBULAR HINGE AXIS

The force exerted by the jaw in closing is not truly vertical due to the hinge axis. The resultant arc *(R)* of closure can be broken up into its vertical *(V)* and mesial *(M)* components (Fig. 1). This means that as the mandible is closed to occlusal contact some of the force is in a mesial direction. The arc of closure in the posterior area *(R_1)* has a smaller radius since it is closer to the condyle. This results in a greater mesial component of force than in the anterior part of the mouth.

ANTERIOR AXIAL INCLINATION: Due to the axial inclination of the anterior teeth, occlusal pressure usually results in less torque on the lower teeth than on the upper teeth. The direction of force is perpendicular to the contacting inclines. The angles of the inclines change in relation to the vertical and horizontal overlap (Fig. 2).

The line of force usually falls closer to the center of rotation of the lower teeth *(d_1* and *d_2)* than on the upper teeth *(D_1* and *D_2)*. The direction changes depending on the relationship of the vertical and horizontal overlap. There is usually more torque on the maxillary anterior teeth than on the mandibular anterior teeth.

POSTERIOR MESIAL AXIAL INCLINATION: The posterior teeth usually have a mesial axial inclination. Occlusal pressure then is not exactly along the long axis of the tooth. The occlusal force *(O)* therefore falls mesial to the center of rotation which results in a mesial component (*M*, Fig. 3). This mesial component of force acts while the patient swallows saliva, during clenching, bruxism, and in the process of mastication and swallowing.

I feel that this force is a potent one particularly when added to the mesial component of the hinge axis of the mandible. The relation of these forces to mesial drift will be discussed later.

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CUSP TO FOSSA ARTICULATION IN CENTRIC RELATION

With a true cusp to central fossa relationship, the stress is as close to being along the long axis of the tooth as possible. Even then, the mesial axial inclination and the mesial component of the hinge axis of the mandible do not permit stress except along the long axis of the tooth. When the cusp of the upper tooth articulates in the distal fossa of the lower tooth, such as in the bicuspids (Fig. 4), torque can develop which modifies the original occlusal direction.

If the tooth was upright, the occlusal load in the distal fossa would fall distal to the center of rotation, causing a distal torque (*D,* Fig. 4). Stress on the cusp height falls in the long axis producing no torque. With a mesial axial inclination of the bicuspid, the same occlusal pressure in the distal fossa may fall very close to the center of rotation. This of course would produce little or no torque. The occlusal load on the cusp height would fall mesial to the center of rotation producing mesial torque (*M,* Fig. 4). The axial inclination of the bicuspids and the occlusal contact will determine whether the resultant torque will be added to or subtracted from the mesial pressure developed posteriorly.

VARIATIONS IN CENTRIC OCCLUSAL CONTACT

Variations in centric occlusal contact change the resultant force from the original occlusal direction. In an ideal buccolingual contact in centric occlusion (Fig. 5), occlusal pressure will produce vectors of force perpendicular to each incline. The lateral affects of *(C* and *B)* on the upper tooth and *(C_1* and *B_1)* on the lower tooth tend to cancel each other. The end result is a buccal torque on the upper teeth and a lingual torque on the lower teeth. Even with an ideal centric occlusal contact, a "vertical stress" results in lateral torque.

With centric contact only on the buccal cusp (Fig. 5), buccal torque is produced on the upper tooth, and lingual torque is produced on the lower tooth. Similarly, with only lingual cuspal contact (Fig. 5), lingual torque is produced on the upper tooth and buccal torque is produced on the lower tooth. In the last two cases, more torque is produced than with good centric occlusal contact. The rationale being that with poor centric occlusal contact, the entire occlusal load produces torque. With good centric occlusal contact, two-thirds of the occlusal load is neutralized for torque production (*C* and *B,* Fig. 5), leaving only one-third *(A)* available for torque production.

BUCCAL AND LINGUAL AXIAL INCLINATION

Because of the buccal axial inclination of the upper teeth, and the lingual axial inclination of the lower teeth, "vertical" occlusal pressure will cause torque. The vertical forces (*O_1* and *O_2,* Fig. 6) fall outside the center of rotation and produce buccal torque on the upper teeth *(B)* and lingual torque on the lower teeth *(L).*

LATERAL ECCENTRIC MOVEMENTS

On the working side, during bruxism or functional movements, buccal torque develops on the upper tooth and lingual torque develops on the lower tooth. It is also important to note the articulation of the teeth from the buccal view, as it

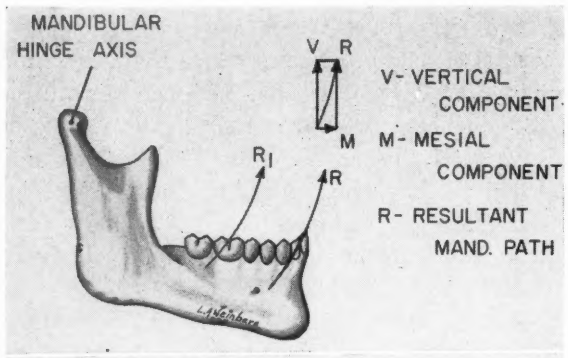

Fig. 1.—Mandibular hinge axis: The force exerted by the jaw in closing is not truly vertical due to the mandibular hinge axis. The resultant arc *(R)* of closure can be broken up into its vertical *(V)* and mesial *(M)* components.

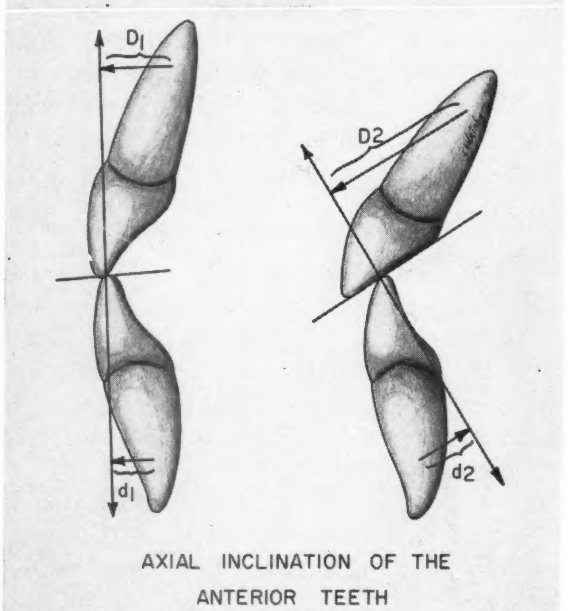

Fig. 2.—Anterior axial inclination: Due to the axial inclination of the anterior teeth, occlusal pressure usually results in less torque on the lower teeth than on the upper teeth. The line of force usually falls closer to the center of rotation of the lower teeth (d_1 and d_2) than on the upper teeth (D_1 and D_2). The direction of force changes, depending on the vertical overlap. *Left,* A shallow vertical overlap. *Right,* A deep vertical overlap.

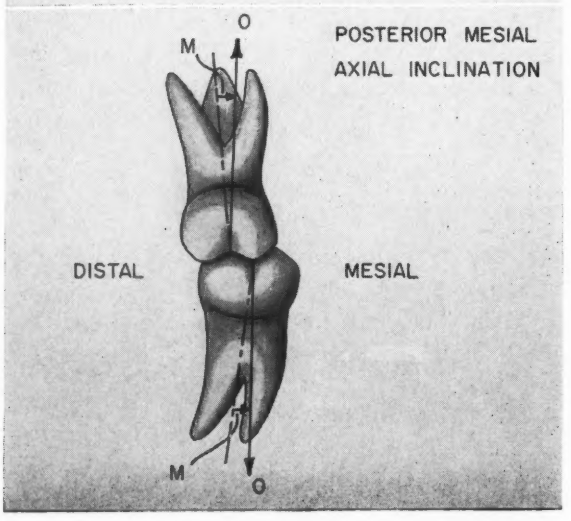

Fig. 3.—Posterior mesial axial inclination: Due to the mesial axial inclination of the posterior teeth, occlusal pressure *(O)* falls mesial to the center of rotation which results in a mesial component *(M)* of force.

is significant in the production of mesial or distal forces. The upper second bicuspid (Fig. 7) has mesial and distal incline contact. Occlusal pressure results in mesial and distal forces perpendicular to the inclines *(M* and *D)* as these teeth move in lateral eccentric position. The mesial and distal effects of these forces tend to cancel each other. If this tooth only has mesial incline contact (Fig. 7) in lateral eccentric movements, the occlusal force results in distal torque on that tooth.

WORKING SIDE OCCLUSION IN RELATION TO TORQUE

If the mesial inclines of the upper teeth contact the distal inclines of the lower teeth in lateral eccentric movements, the forces will be perpendicular to

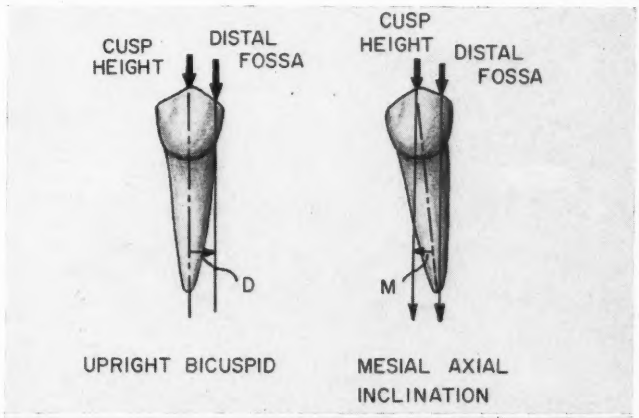

Fig. 4.

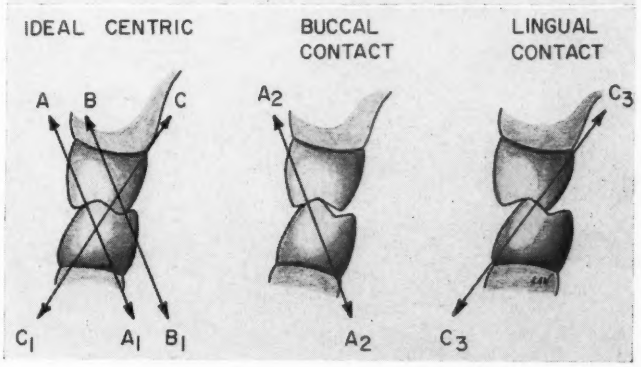

Fig. 5.

Fig. 4.—Cusp-to-fossa articulation in centric occlusion: If the bicuspids were upright *(Left)*, the occlusal load in the distal fossa would fall distal to the center of rotation causing a distal torque *(D)*. Stress on the cusp height falls in the long axis producing no torque. With mesial axial inclination *(Right)* the same occlusal pressure in the distal fossa may fall very close to the center of rotation producing little or no torque. The occlusal load on the cusp height would fall mesial to the center of rotation producing mesial torque *(M)*.

Fig. 5.—Variation in centric contact: Occlusal pressure with ideal centric occlusal contact *(Left)* produces vectors of force perpendicular to each incline. The lateral effects of *C* and *B* on the upper teeth and C_1 and B_1 on the lower teeth tend to cancel each other. The end result is a buccal torque on the upper teeth and a lingual torque on the lower teeth. With centric occlusal contact only on the buccal cusp *(Center)*, buccal torque is produced on the upper tooth and lingual torque on the lower tooth. Similarly, with only lingual cuspal contact *(Right)*, lingual torque is produced on the upper teeth and buccal torque on the lower teeth.

the inclines (*Left,* Fig. 8). Therefore, during bruxism and lateral excursions there will be distal torque on the upper teeth and mesial torque on the lower teeth.

If the opposite incline relationship were to exist (*Right,* Fig. 8, distal inclines of the upper teeth with the mesial inclines of the lower teeth) then, during lateral movements, mesial torque on the upper teeth and distal torque on the lower teeth would result.

This mesial and distal torque production can be very significant when there is a lack of interproximal contact or when these teeth are acting as abutments. When both mesial and distal inclines are in contact in lateral eccentric movements, the mesial and distal effects tend to cancel each other (*A* and *B,* Fig. 9). The vector diagram in Fig. 9 shows how forces *(A* and *B)* produce the vertical resultant *(R).* A prematurity concentrates the power of the musculature in one area producing tremendous torques. This should be relieved according to the corrective procedures which eliminate the etiology of the trauma.[2-6]

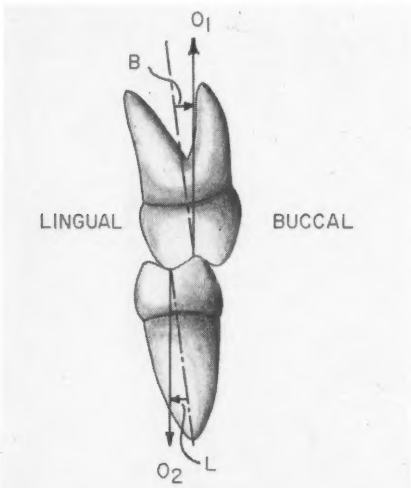

Fig. 6.

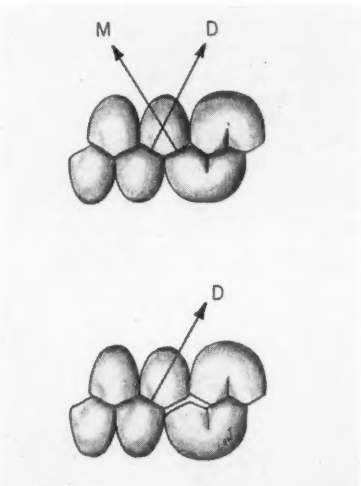

Fig. 7.

Fig. 6.—Posterior buccal and lingual axial inclination: Because of the buccal axial inclination of the upper teeth, occlusal pressure *(O_1)* falls buccal to the center of rotation causing a buccal torque *(B).* Due to the lingual axial inclination of the lower teeth, occlusal pressure *(O_2)* falls lingual to the center of rotation causing lingual torque *(L).*

Fig. 7.—Lateral eccentric contact: The upper second bicuspid has mesial and distal incline contact in lateral eccentric movements *(Top).* Occlusal pressure results in mesial and distal forces perpendicular to the inclines *M* and *D.* The mesial and distal effects of these forces cancel each other. If this tooth only has mesial incline contact *(Bottom)* then occlusal pressure results in distal torque on that tooth.

MESIAL DRIFT

The topic of mesial drift has so many ramifications that I will limit my discussion to its relationship with axial inclination and cuspal articulation.

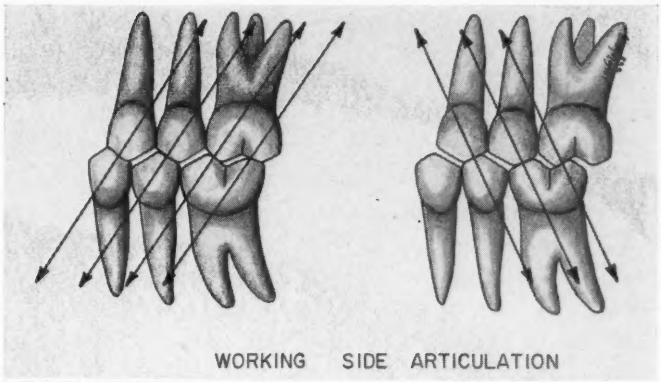

Fig. 8.

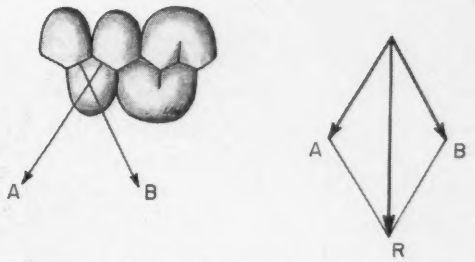

Fig. 9.

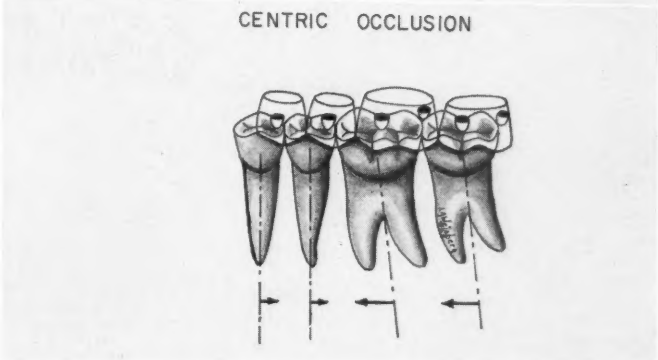

Fig. 10.

Fig. 8.—Working side articulation: When the mesial inclines of the upper teeth contact the distal inclines of the lower teeth in lateral eccentric movements, the forces will be perpendicular to the inclines *(Left)*. During bruxism and lateral excursions, there will be distal torque on the upper teeth and mesial torque on the lower teeth. If the distal inclines of the upper teeth articulate with the mesial inclines of the lower teeth *(Right)*, then mesial torque on the upper teeth and distal torque on the lower teeth would result.

Fig. 9.—When both mesial and distal inclines are in contact in lateral eccentric movements, the mesial and distal effects tend to cancel each other. Vectors *(A)* and *(B)* produce a vertical resultant *(R)*.

Fig. 10.—Centric occlusion in relation to mesial drift: Occlusal pressure on the molar teeth can cause mesial torque due to the mesial axial inclination. The lingual cusps of the upper bicuspids articulate in the distal fossae of the lower. If the bicuspids are upright, the line of force falls distal to the center of rotation, resulting in distal torque. This distal torque helps resist the mesial forces developed posteriorly.

MANDIBULAR HINGE AXIS: The hinge axis of the mandible (Fig. 1) has an anterior component which is continuously acting in swallowing, mastication, bruxism, and clenching. This anterior force is present whenever any occlusal force is applied, regardless of the axial inclination or articulation of the teeth. Due to these latter relationships, however, forces may develop that add to or subtract from the anterior component of the hinge axis.

As an example, if the vertical overlap were severe (*Right,* Fig. 2), the line of force developed by occlusal pressure could be distal to the axis of rotation of the lower tooth. This would result in a posterior force on the tooth which would subtract from the anterior component developed by the hinge axis of the mandible. On the other hand, if the vertical overlap were less severe (*Left,* Fig. 2), the line of force developed by occlusal pressure could fall anterior to the center of rotation of the lower tooth. In this case, the anterior torque on the tooth would be added to the effects of the anterior component of the hinge axis of the mandible.

MESIAL AXIAL INCLINATION: Due to the mesial axial inclination of the posterior teeth (Fig. 3), occlusal pressure can result in an anterior component of force. This would be added to the anterior component of the hinge axis of the mandible and distributed by the contact points.

CENTRIC OCCLUSION: Occlusal contact in centric position has an important relationship to mesial drift. The teeth contact in centric occlusion as the patient swallows many hundreds of times a day. If we have an "ideal" cusp-to-fossa relationship in centric occlusion (Fig. 10), occlusal pressure on the molar teeth causes a mesial component of force. This is due, in part, to the mesial axial inclination of these teeth. The lingual cusps of the upper bicuspids articulate in the distal fossa of the lower bicuspids. The line of force may fall distal to the axis of rotation resulting in a distal component of force. This distal force is usually small, but it can help diminish the effects of the mesial component originating posteriorly. If the bicuspids have a marked mesial axial inclination (*Right,* Fig. 4), the line of occlusal force may fall mesial to the center of rotation, causing a mesial component of force. This would be added to the mesial components of force developing posteriorly.

The resultant torque of the bicuspids in centric occlusal contact has a stabilizing effect on the dynamic forces originating posteriorly. The mesial forces that are not neutralized here will have to be neutralized elsewhere. The residual mesial forces on the left and right side should meet at the midline and neutralize each other. This depends on good interproximal contact and alignment. There is no question that muscular forces play an extremely important role which we have arbitrarily omitted from this discussion.

DEVIATION IN CENTRIC OCCLUSION: When there is a deviation from the hypothetical centric contact, marked changes occur. The ideal cusp-to-fossa relationship initiates mostly vertical forces which can result in various torques, depending on the axial inclination of the tooth. In other words, the torque is produced by the vertical force falling outside the "base line" or, more technically, outside the center of rotation.

If we have poor centric occlusal contact, such as a cusp to an incline, occlusal pressure no longer initiates vertical force. The occlusal pressure is now perpen-

dicular to whatever incline exists (Fig. 5). The line of force can be extremely distant from the center of rotation of the tooth, thus producing severe torque. We would then have to correlate this torque with the other known forces in that particular case to evaluate its effect.

LATERAL ECCENTRIC CONTACT: In mastication, the teeth do not always penetrate the bolus. The food that is unable to escape distributes the occlusal forces to the teeth as if the teeth were in contact. Lateral contact becomes extremely important in relation to the mesial drift when the patient shows evidences of bruxism and clenching.[7] In these cases, the torques that develop in lateral eccentric movements are much more active than when the patient only uses these lateral movements for mastication.

In lateral eccentric movements, if the distal inclines of the lower teeth articulate with the mesial inclines of the upper teeth (*Left,* Fig. 8), the lower teeth will have a mesial component of force exerted on them. This will be added to the mesial components of force resulting from the mesial axial inclination of the teeth and the hinge axis of the mandible.

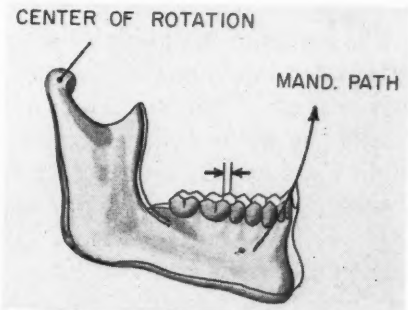

Fig. 11.—Marked occlusal wear: A reduction in vertical dimension results in an anterior movement of the mandible in relation to the maxillae. This is due to the arc of rotation of the mandible. The superimposed drawing shows the relative position of a fixed point as the mandible swings upward and forward.

When the mesial inclines of the lower teeth and the distal inclines of the upper teeth contact in lateral eccentric movements, distal torque on the lower teeth develops (*Right,* Fig. 8). This torque will help neutralize the mesial components developed due to the mesial axial inclination and the hinge axis of the mandible. In both cases, any break in interproximal contact will allow a severe torque to be applied to the tooth involved.

INTERPROXIMAL WEAR: The interproximal wear that takes place, due to the minute tooth movements, is compensated for by mesial drift. If this were not so, interproximal spaces would develop. Therefore, interproximal wear itself becomes a factor in mesial drift. It does not exert a mesial force per se, but it allows a space which is closed by the mesial forces present.

OCCLUSAL WEAR: Occlusal attrition is usually compensated for by continuous eruption. In this case no significant reduction in vertical dimension takes place. When the attrition rate is very high due to habit, food, or malformed teeth, a reduction in vertical dimension can take place.

The reduction in vertical dimension is the significant point. A reduction in vertical dimension results in an anterior movement of the mandible in relation to the maxillae. This is due to the arc of rotation of the mandible (Fig. 11). The anterior movement of the mandible in this case does not mean that the condyle slides forward in the fossa. The condyle rotates and establishes a new centric relation at this vertical dimension.

Normal physiologic wear does not usually cause a change in maxillomandibular relationship. Rapid occlusal wear with a loss in vertical dimension causes the mandible to move mesially in relation to the maxillae. This is not "mesial drift" in the usual sense applied to teeth. We could apply the term "mesial mandibular drift" to make the distinction.

SUMMARY

Occlusal stress purely in the long axis of the tooth rarely exists. Even the apparent vertical pressure of the mandible in centric occlusion has an anterior component due to the hinge axis of the mandible. The mesial axial inclination of the posterior teeth also helps convert "vertical" pressure into torque. The line of force of an occlusal load often falls mesial to the center of rotation of the tooth. Thus occlusal pressure is converted into a mesial torque.

A cusp to central fossa relation in centric occlusion is the closest we can come to stress on the long axis of the teeth. In the bicuspid articulation, the upper lingual cusp articulates in the distal fossa of the lower; distal torque often develops. The axial inclination of these teeth can completely change the direction of the torque produced.

Good centric occlusal contact results in buccal torque on the upper teeth and lingual torque of the lower teeth. The amount of torque is usually less than when there is poor centric contact. In any case, torque is also produced due to the buccal axial inclination of the upper teeth and the lingual axial inclination of the lower teeth. This is added to the torque resulting from the centric occlusal articulation.

Occlusal pressure in centric occlusion results in torque production from several possible sources: (1) the anterior component of the hinge axis of the mandible, (2) the mesial torque produced by the mesial axial inclination of the posterior teeth, (3) buccal and lingual torque produced by the buccal and lingual axial inclination of the upper and lower teeth, respectively, (4) occlusal contact in relation to the center of rotation of the tooth, and (5) incline plane relation in centric occlusion produces torque.

All of these torque-producing factors act at one time or another when the teeth are in contact. At any given moment, various torques may be acting at one time to produce a resultant torque. As the teeth function and change their relationship, the resultant torque keeps changing. To say that this is a dynamic system is quite an understatement.

Some of these torques play a part in the phenomena of mesial drift. They are: (1) the anterior component of the hinge axis of the mandible (active in all occlusal contact), (2) the mesial axial inclination of the posterior teeth, (3) the

incline plane relation in centric position, (4) the incline plane relation in eccentric positions, and (5) interproximal wear (indirect association with mesial drift).

The physiologic forces influencing the periodontal support are so complicated that this discussion only scratches the surface. We feel that studies of muscle action and individual habit patterns should be correlated with occlusal forces. Perhaps then a better understanding of the stresses that are distributed to the periodontal structures could be obtained.

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REMOVAL OF JACKET CROWNS

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IF A JACKET CROWN must be removed for diagnosis, treatment of pulpitis, endodontic treatment, or with the intention to replace it at a later date with a new jacket crown, it is desirable that it be not destroyed or injured, in order that it could be used again, either temporarily or permanently.

Jacket crowns may be removed by means of a copper band filled with modeling compound, which, when placed over the crown and cooled, will act as a splint and prevent fracture or injury to the crown as it is removed.

PROCEDURE

1. A slightly oversized copper band is selected and contoured to the gingival margin of the tooth involved. In some instances, it will be necessary to cut the band slightly on the mesial and distal sides with a disk in order to seat the band interproximally.

2. Several holes are made in the band with a No. 35 inverted cone bur. This is done on the labial, lingual, mesial, and distal surfaces.

3. The copper band is placed in position on the tooth, and a hole is made straight through the band, from the labial side to the lingual side, as close to the incisal edge of the jacket crown as possible. It is important that these holes are prepared in this position so that there will be sufficient copper band and bulk of modeling compound to prevent the ligature wire from tearing loose when the removal of the jacket crown is attempted.

4. A heavy ligature wire is inserted through the last set of holes, and the ends of the wire are braided to form a loop (Fig. 1).

5. The copper band is removed and filled with softened modeling compound, then the band is reseated on the dried tooth, and the modeling compound is allowed to cool thoroughly.

6. A sturdy instrument handle is inserted through the loop formed by the ligature wire. The patient, or assistant, is instructed to grasp each end of the handle and apply as much tension as possible, in a direction along the jacket crown's path of withdrawal.

7. While the patient, or assistant, maintains this tension on the copper band, the dentist administers a sharp blow to the instrument handle with a surgical mallet. This blow should be as close to the ligature wire as possible and directed

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The opinions or assertions contained herein are those of the author and are not to be construed as official or as reflecting the views of the Air Force or the Air Service at large.

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along the withdrawal path of the jacket crown (Fig. 2). One blow generally suffices to dislodge the jacket crown and copper band.

8. The copper band, with the jacket crown embedded in the modeling compound, is then placed in warm water. When the modeling compound has softened sufficiently, the jacket crown is easily removed intact.

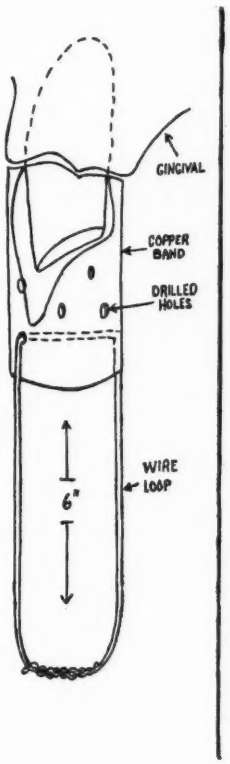

Fig. 1.

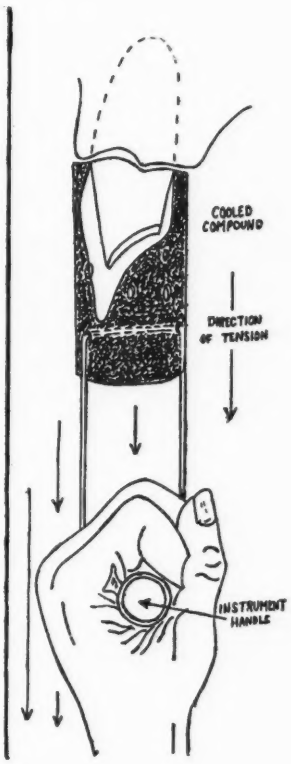

Fig. 2.

Fig. 1.—The copper band is fitted to the crown and a ligature wire loop is attached to the copper band.

Fig. 2.—The copper band is filled with modeling compound, chilled, and tension is applied to the handle along the path of withdrawal of the crown.

This technique has been employed with success in the removal of jacket crowns and acrylic resin veneers in the anterior portion of the mouth. A limited degree of success can be expected when attempting to remove gold crowns from posterior teeth, because the forces cannot be applied along the path of withdrawal, and the area of retention is greater.

BRIDGE REMOVAL

This technique can also be used for the removal of anterior porcelain or acrylic bridges with minor variations.

1. The same type of copper band attachment is used for each of the two abutment teeth as used for jacket crowns. The braided ligature wire extending from the bands should be approximately the same length. The copper bands are removed, filled with softened modeling compound, reseated on the dried teeth, and cooled.

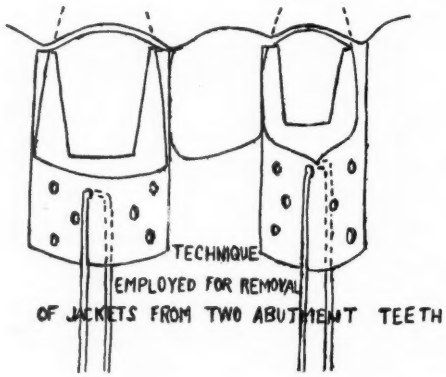

Fig. 3.—Copper bands and wire loops placed on two abutment teeth for the removal of a bridge.

2. The instrument handle is then placed through *both* loops; the loops being placed in such a position as to be parallel to the line of withdrawal (Fig. 3). The patient, or assistant, is instructed to grasp each end of the handle and apply as much tension as possible in such a direction as to remove the bridge along its path of withdrawal.

3. While tension is maintained, a sharp blow with a surgical mallet is administered to the instrument handle between the ligature wires. This blow should be directed along the withdrawal path of the bridge. It may take several blows to dislodge the bridge. The procedure for the removal of the bridge from the copper bands is the same as that used for a jacket crown.

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A STUDY OF ADAPTATION OF VENEERS TO CAST GOLD CROWNS

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FAILURE OF PARTIAL VENEER crowns, either through separation of the veneer material from the gold or by discoloration of the veneer material itself, has long been a problem in crown and bridge prosthodontics. Discoloration has generally been attributed, at least in part, to the infiltration of fluids and debris between the veneer and the cast gold crown. Lamstein and Blechman,[1] in a study employing both dyes and bacteria, have shown that this type of leakage does occur with acrylic resin veneers. In view of the nature of the luting material, it would seem logical to assume that such leakage would also occur whenever porcelain veneers are cemented with the conventional zinc phosphate cement. Undoubtedly, some solution of the cement does take place, and the bond between the gold and the veneer is weakened.

One of the objectives in the development of new materials and techniques has been to minimize this leakage and thus to assure indefinite esthetics. Particular promise is held for veneers made of porcelain which are fused or baked onto the cast gold crown.[2,3] Since leakage is primarily associated with adaptation, it was the purpose of this investigation to evaluate the adaptation of these new materials with that of the conventional type veneers.

PROCEDURE

The penetration of radioisotopes around restorations placed in extracted teeth has been employed as a means of studying adaptation of restorative materials.[4-6] It was felt that this test method would be the one most applicable to this particular problem, and hence it was used in this study.

The procedure was essentially that used by Crawford and Larson.[6] The radioisotope employed was Ca^{45}, the concentration of the solution being 1 mc. per 10 ml. of solution. The solution was adjusted to pH 6.0 with dilute sodium hydroxide.

Gold castings, of standard design for veneered gold crowns,[7] were used as the castings in all cases. A minimum of 3 veneers was prepared from each of the following materials and techniques: silicate, heat-cured acrylic resins, and self-cured acrylic resins. The heat-cured acrylic resin veneers were packed in the conventional manner, placed in cold water, and brought to a boil in 30 minutes. After boiling for 30 minutes, they were bench cooled.

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Four porcelain veneers were cemented with zinc phosphate cement to another group of 4 crowns. Crowns with fused porcelain veneers prepared in a variety of ways were also tested. One group of 12 crowns was prepared from Neyoro Porcelain. Six were fused in air and the other 6 in vacuum. The exact firing cycles were as follows:

Air Fired

Opaque: in furnace at 1100° F., heated to 1450° F. at 100° per minute.
Body first biscuit: in furnace at 1100° F., heated to 1650° F. at 100° per minute and out.
Second biscuit: in furnace at 1100° F., heated to 1650° F. at 100° per minute and out.
Glaze: in furnace at 1100° F., heated to 1650° F. at 100° per minute, held 1 minute and out.

Vacuum Fired

Opaque: in furnace at 1100° F., vacuum applied, heated to 1400° F. at 100° per minute, vacuum broken and removed from furnace.
Body biscuit: in furnace at 1100° F., vacuum applied, heated to 1550° F. at 100° per minute, vacuum broken and removed.
Second biscuit: in furnace at 1100° F., vacuum applied, heated to 1550° F. at 100° per minute, vacuum broken and removed.
Glaze: in furnace at 1100° F., heated in air to 1650° F. at 100° per minute and held for 1 minute.

Six additional crowns, also prepared from Neyoro Porcelain, were secured from a commercial laboratory. These were vacuum fired, 3 being glazed, and the other 3 unglazed. Four veneered crowns fabricated from Permadent were processed and obtained from a commercial laboratory.*

The crowns were placed in the radioisotope solution and removed at intervals ranging from 3 days to 3 weeks. Upon removal, they were rinsed, then brushed with a detergent, and again thoroughly rinsed in running water. Longitudinal sections were prepared by grinding on a wet Carborundum wheel. The wheel was dressed after each section was made in order to prevent any transport of the radioactive material from one specimen to another.

In making autographs, the cut surfaces were brushed with a detergent before being placed in contact with the film. After considerable experimentation, an exposure time of 20 hours was selected. The autographs were generally quite sharp, and little fogging occurred. Eastman ultraspeed dental x-ray film was employed, with a developing time of 4 minutes.

RESULTS

The autographs shown in Figs. 1 to 9 are representative of crowns which were immersed in the radioactive solution for 3 weeks. It will be noted that there was some infiltration of the isotope between the veneer material and the gold casting, except in those specimens where the porcelain was baked on the gold and then fused in air. Even within only 3 days, the radioactive material had penetrated beneath the veneers prepared from silicate cement. The fogging of the film noted in Fig. 1 was common to all autographs of this material and was assumed to be due to sorption of the isotope by the silicate surface. This was not noted with any of the other materials tested. Porcelain veneers placed with zinc phosphate cement also exhibited leakage within 3 days (Fig. 2).

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Although the veneers prepared from both the autopolymerizing and the heat-cured resins gave evidence of infiltration between the gold and the veneers (Figs. 3 and 4), the leakage was not as rapid with these materials as with the silicate veneer or the porcelain cemented on with zinc phosphate cement.

Fig. 1. Fig. 2.

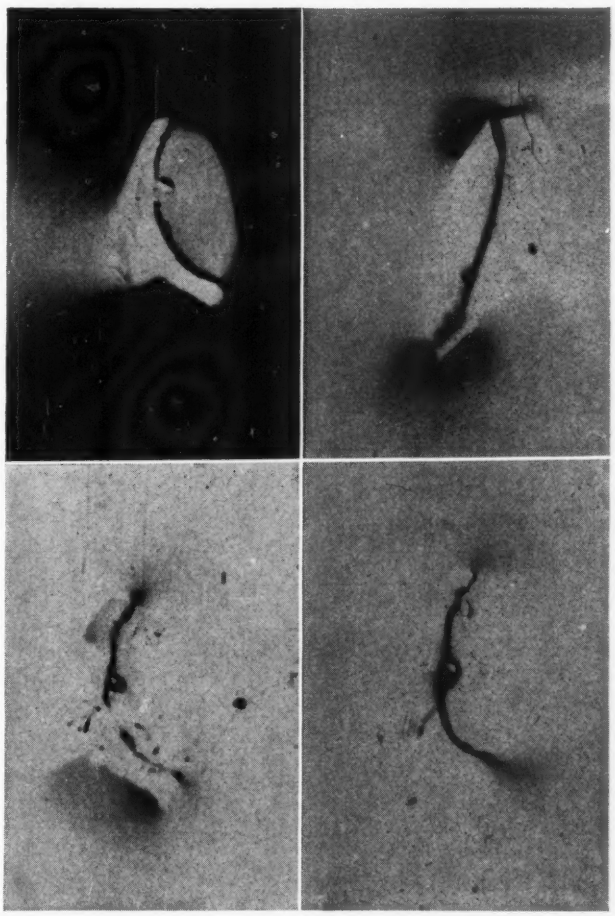

Fig. 3. Fig. 4.

Fig. 1.—A silicate veneer. (Note: In this and all other autographs, the isotope penetration is denoted by the dark line between the casting and veneer material.)

Fig. 2.—A porcelain veneer cemented with zinc phosphate cement.

Fig. 3.—An autopolymerizing resin veneer.

Fig. 4.—A heat-cured resin veener.

As can be seen in Figs. 5 and 6, the Ca^{45} had not penetrated between the gold and the fused porcelain veneers of either the Neyoro Porcelain or Permadent, fired in air, even after 3 weeks' exposure to the radioactive solution. Autographs

of specimens with the fused porcelain veneers which were vacuum fired appear in Figs. 7, 8, and 9. Some marginal leakage was observed after 3 weeks in all cases where this procedure was employed. There was, however, no apparent infiltration in any of the crowns sectioned before this time. No difference was noted in the glazed and unglazed specimens.

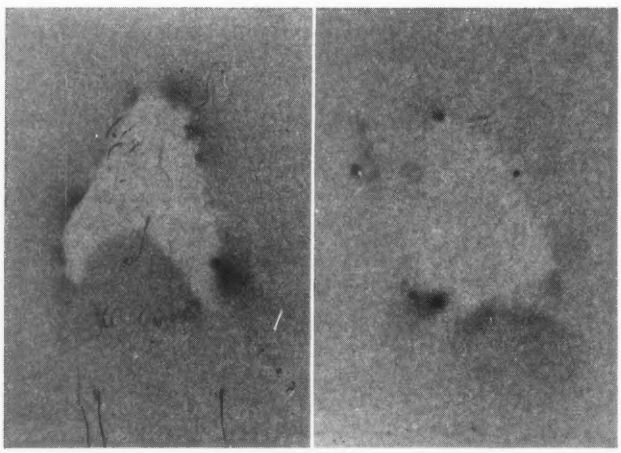

Fig. 5. Fig. 6.

Fig. 5.—Neyoro porcelain veneer—air fired.
Fig. 6.—A Permadent veneer.

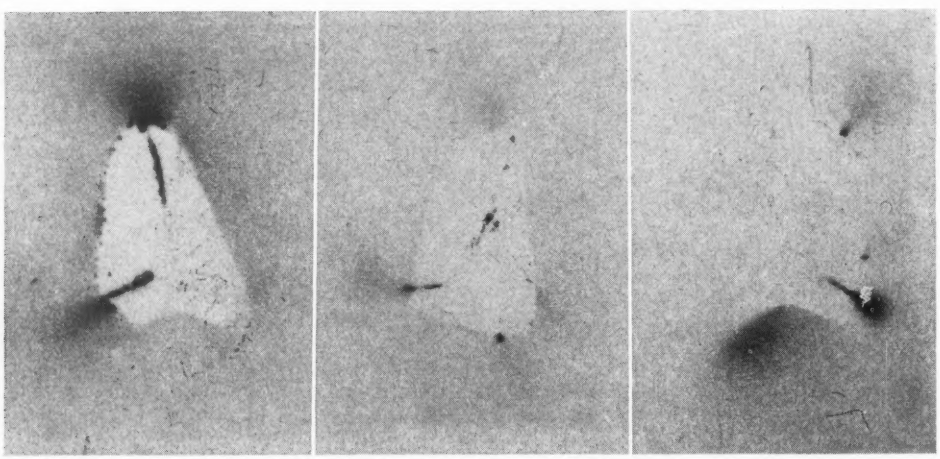

Fig. 7. Fig. 8. Fig. 9.

Fig. 7.—A Neyoro porcelain veneer—vacuum fired.
Fig. 8.—A Neyoro porcelain veneer—vacuum fired, but not glazed (prepared by commercial laboratory).
Fig. 9.—A Neyoro porcelain veneer—vacuum fired and glazed (prepared by commercial laboratory).

DISCUSSION

The fact that little or no leakage occurred with the crowns where the porcelain was baked on or fused to the gold was particularly impressive in view of the heroic nature of the test employed. The calcium molecule is an extremely small one, allowing it to penetrate a most minute space. This is emphasized by the fact that, thus far, the results of experiments employing radioactive calcium for studying the adaptation of restorations indicate that all restorations leak.[4, 5, 6, 8, 9] These experiments with the baked-on porcelain do not necessarily prove an actual chemical bonding of the porcelain to the gold but certainly indicate the existence of a very intimate relationship between the two. It is obvious that a very close adaptation is secured, far superior to that obtained with any materials previously used for this purpose.

There are, of course, many things such as esthetics, strength, ease of manipulation and repair which must be considered in the clinical use of these materials. Likewise, the exact clinical significance of these findings is most difficult to interpret. It is possible that biting stress and the difference in the elastic and thermal properties between the porcelain and metal could markedly influence the original adaptation. Certainly additional research on these variables is needed. However, it does appear that the particular property investigated in this research is a most important one and provides certain basic information. From these initial tests, it might be expected that the discoloration attributed to the infiltration of fluids and debris would be reduced, and that the failures due to separation of the veneer from the gold casting would be minimized.

No explanation is offered for the lesser adaptation of the vacuum fired specimens, nor again can one predict the clinical significance of this finding. The data do, however, indicate a need for further study of this variable.

SUMMARY

The adaptation of various veneer materials to gold was compared by studying the penetration of radioisotopes between the veneers and the cast gold crown. The veneer materials evaluated were silicate, acrylic resin, porcelain cemented with zinc phosphate cement, and 2 baked-on porcelain techniques. By this test, the porcelain materials fused to the gold, particularly when fired in air, appeared to be quite superior to the other materials studied. Even though the adaptation of these materials is reduced when they are fired in vacuum, the rate and degree of infiltration was markedly less than with the acrylic resins, cemented porcelain, or silicate veneers.

The authors wish to acknowledge the cooperation of The J. M. Ney Company, Kramer Laboratories, Mr. Harry Dunton, and Dr. Roland Dykema who prepared many of the test specimens.

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REPORT OF THE COMMITTEE ON SCIENTIFIC INVESTIGATION* THE AMERICAN ACADEMY OF RESTORATIVE DENTISTRY

PART I: DENTAL CARIES

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DOUBT CAN BE THE provocative asset of a healthy, scientific mind. The field of dental caries has, for many years, been a subject for much controversy. This controversy has been one of the stimulating forces leading to good, scientific research. We, of the dental family, are grateful to the many workers in this field. They have given answers of benefit to the health of the people of our country.

FLUORIDATION

In this report, we shall briefly summarize some recent research conclusions. Jay and Bennett[1] make a timely and challenging statement: "Fluoride (F), ingested during the tooth development period, and sugar as well as other carbohydrate, in some individuals, are the only dietary factors that thus far have been satisfactorily demonstrated to be related to caries activity in human beings."

The most recent report by Arnold and others[2] brings to us a forceful, scientific documentary of this project. Dentistry will some day receive a justified "pat on the back" for the good health that this type of research will bring to many people. Today, people in all walks of life are asking questions about water fluoridation. It is important that dentists be prepared to answer all questions on this subject. With this thought in mind we quote the discussion and summary of this article.[2]

"From the results obtained in Grand Rapids after 10 years of water fluoridation, it is quite clear that this procedure is remarkably effective in reducing the incidence of dental caries. These observations are in accord with the results of similar studies conducted under separate auspices. The scientific evidence is conclusive, therefore, that water fluoridation is an effective public health procedure for producing a substantial reduction in the incidence of dental caries.

"According to this study, the beneficial effects of fluoridated water are not confined to persons drinking the water since birth. The results suggest that some benefit was obtained by persons whose teeth had already formed or erupted when they started drinking fluoridated water. The effects on the teeth of adults in these cities have not as yet been ascertained. However, the fact that a reduction in caries was observed for teeth which had already been calcified when fluoridation was started indicates that some beneficial effect may be gained by older age groups.

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*George M. Hollenback, D.D.S., Chairman.

"The possibility of an increase in dental fluorosis in a community after fluoridation has received considerable discussion. After 10 years of fluoridation in Grand Rapids, the percentage of children classed as having fluorosis has increased, but, as anticipated, this increase is confined to the milder forms. As pointed out previously, the signs of the milder forms of fluorosis caused by ingestion of water containing 1 p.p.m. fluoride as a rule do not appear on the anterior teeth. It is the plan of this study to continue the observations to evaluate this factor fully. Thus far, however, the ingestion of the Grand Rapids water supply has not produced any undesirable cosmetic effect in the form of objectionable dental fluorosis on the anterior teeth."[2]

They summarize their article as follows:

"The results of the Grand Rapids-Muskegon study after 10 years of observation, indicate that the adjustment of the fluoride content of a communal water to an optimal level (approximately 1 p.p.m. fluoride) will produce the following effects:

"1. A striking reduction in the prevalence of dental caries in the deciduous teeth. At the peak of prevalence, namely 6 years of age, the caries rate for the deciduous teeth was reduced by about 54 percent.

"2. A marked reduction in the prevalence of dental caries in the permanent teeth. In children born since fluoridation was put into effect, the caries rate for the permanent teeth was reduced on the average by about 60 percent.

"3. Some benefit among persons whose teeth having already formed or erupted when fluoridation is begun.

"4. No undesirable cosmetic effect from dental fluorosis."[2]

SUGAR AND DENTAL CARIES

Another problem that holds a high priority in scientific and social discussions is sugar and dental caries. We quote from the Joint Report of the Council on Dental Health and the Council on Dental Therapeutics of the American Dental Association.[3]

"In 1943, reporting on his ingenious laboratory study of the process of caries, Dietz pointed out the conditions essential for dental caries. They are (1) a caries-susceptible individual; (2) the presence of acid-producing and acid-tolerating bacteria which are capable of producing (3) an optimum bacterial enzyme system; (4) the presence of orally fermentable carbohydrate; (5) an adherent bacterial plaque. Some other oral conditions may modify the activity of caries. These conditions include types of proteolytic bacteria; flow, consistency, neutralizing power and antibacterial action of saliva; irregularity of teeth or tooth surfaces which contribute to the ready formation of a plaque; the presence or absence of certain amino acids and vitamin fractions, and the rate of solubility of enamel in organic acids. Practically all of these additional conditions, however, have to operate through a bacterial plaque, so only the five highly essential factors will be documented. Jay in 1951 stated these essential factors succinctly and listed four methods for preventing dental caries:

" '1. The complete restriction in the diet of the substances from which acids are produced.

" '2. The inhibition of the enzyme activity which is responsible for the acid production.

" '3. The elimination from the oral flora of the bacteria which produce the enzymes.

" '4. The reduction of the solubility of the tooth surfaces.' "[3]

In 1942, the Council on Foods and Nutrition of the American Medical Association submitted a report on the consumption of sugar.

" 'The per capita gross consumption of sugar in the United States increased steadily from about 10 pounds (4.5 kg.) in 1821 to 108 pounds (49 kg.) in 1931 . . . . Sugar, as consumed in recent years, whether it originates from sugar cane or sugar beets is for the most part highly refined sugar . . . .' "

"Another report on nutrition by the American Medical Association, in 1942, may be quoted

'Sugar is not among the recommended foods. Its recent rationing will not provoke a hardship, for sugar supplies nothing in nutrition but calories, and the vitamins provided by other foods are sapped by sugar to liberate these calories. One of the worst of the many bad food habits that Americans have acquired is their use of sweetened carbonated beverages. Many persons take such beverages by the half pint many times a day with a resultant excessive consumption of sugar.' "[3]

In 1940, Miller, Muntz, and Bradel[8] demonstrated that plaque material removed from teeth produced lactic acid readily from sucrose and maltose but to a much lesser degree from lactose, indicating that milk, from a cariogenic as well as a nutritional standpoint, appears to be a more desirable beverage than a sweetened drink for a school lunch.

"The decalcifying effect of sweetened beverages and fruit juices has been examined in sufficient detail to warrant certain conclusions:

"(a) Research has shown that some sweetened drinks and some natural fruit juices decalcify teeth because of their acidity.

"(b) Decalcification has been observed when either are consumed in large amounts or at frequent intervals.

"(c) Decalcification probably should not be significant unless such solutions are consumed in large amounts or at frequent intervals.

"(d) Fruit juices provide some of the valuable food elements of human diets, while prepared soft drinks provide nothing but calories.

"5. The examination of the scientific literature on the cariogenic properties of soft drinks and fruit juices also justifies a number of conclusions:

"(a) Any sugar solutions, in order to stimulate caries, must be capable of diffusing into the adherent dental bacterial plaques on teeth.

"(b) Available evidence indicates that starchy carbohydrates are of minor importance in the process of caries since complex carbohydrates cannot diffuse into bacterial plaques and cannot be degraded promptly to simple sugars in most mouths.

"(c) Monosaccharides and disaccharides diffuse readily into bacterial plaques.

"(d) The retention time of carbohydrates in the saliva appears of much less importance in the caries process than the retention time of simple sugars in bacterial plaques and the inability of the saliva to contact rapidly and buffer the acid produced under plaques.

"(e) It has been demonstrated that solutions of simple sugars are degraded promptly to lactic acid in the bacterial plaques of caries-active individuals.

"(f) This production of acid from retained solutions of sugar may continue in plaques for one-half to three hours following a brief rinse of the patient's mouth with a 10 per cent solution.

"(g) The dental plaque appears to have the ability to store acid and to hinder the saliva from neutralizing it.

"(h) The pH of an individual's saliva can be too high for decalcification to take place while, at the same time, the pH in a bacterial plaque becomes so low that decalcification occurs rapidly.

"(i) Solutions of some natural sugars, such as lactose, and sorbitol are fermented with difficulty in the human mouth.

"(j) Data regarding the cariogenic potentialities of solutions of simple sugars that are derived from studies of laboratory rats must be appraised critically by dentists since great variations in susceptibility to caries exist for a number of strains of these animals and findings can be prejudiced merely by the selection of the strain of animal and the physical qualities of the diet which he is fed in an experimental situation."[3]

CONCLUSIONS

"1. The dental profession and other interested agencies have a responsibility to warn the public of the cariogenic property of sugars and their solutions and to point out that many of these products contain no highly important nutritional factors.

"2. Research should be encouraged on the part of producers of sweetened beverages and confections to support the development of new or improved procedures or agents for the prevention and control of dental caries which may result from the use of their products."[3]

As a reference for the role of dentifrices in prevention of caries, we are using the contents of a personal communication from Philip Jay to this committee.*

AMMONIA DENTIFRICES

"In these formulas, it appears that, in general, ammonia is liberated, thus reducing the lactobacilli in the dental plaque. At the present time, the available data do not indicate that any of these dentifrices are sufficiently effective."

PENICILLIN DENTIFRICE

"Lactobacilli are sensitive to penicillin. It is because of this that penicillin was tested as a caries inhibiting agent. Two major studies have been concluded with this dentifrice. One study indicated a favorable reduction of dental caries and the other study demonstrated that the reduction of dental caries was not significant. However, in both instances, penicillin resistant strains of streptococci were observed in children who used the dentifrice. This is the main reason why the dentifrice is not acceptable to the American Dental Association's Council on Dental Therapeutics."

*Jay, Philip: Personal communication, Aug. 30, 1956.

ANTIENZYME DENTIFRICES

This approach is reasonable from the standpoint of our present knowledge of caries activity, but there are not, as yet, sufficient data acceptable to the Council on Dental Therapeutics. This applies to dentifrices containing stannous fluoride as well.

TOPICAL APPLICATION OF FLUORIDE

"We note disagreement as to the effectiveness of topical application of fluoride. Most work has been done with sodium fluoride and in every instance in which it was applied to children, a 40 per cent reduction in caries has been reported. Muhler, of Indiana, reports a higher reduction when stannous fluoride is used instead of sodium fluoride, and he considers it to be effective in dentifrice form. Great differences in findings occur in studies in adults. The study in adults appears unresolved but certainly merits further attention."*

As we review these aids that have come to us in the fight against dental caries, it is important to appraise our position in this program. One of the potent weapons against dental caries is still operative dentistry very well done. Of equal importance is the instruction to the patient in perfect home care and the restriction of carbohydrate in the diet, so that day by day they may help protect the good health we give to them.

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*Jay, Philip: Personal communication, Aug. 30, 1956.

REPORT: PART II

AN APPRAISAL OF RECENT SIGNIFICANT DEVELOPMENTS IN THE PRACTICE OF GENERAL DENTISTRY

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IMPRESSION MATERIALS

DURING THE PAST YEAR, there has been much interest and experimentation with the newer impression materials. This will be reported because it is of practical importance to each of us. The following is the reaction of your reporter to the information and research presented on clinics and in the literature, as well as personal correspondence and clinical experience.

Hydrocolloids.—There is nothing of significance to report in this field that is new, but observation suggests that many of the leading clinicians and operators are using the hydrocolloid materials in fixed bridgework, crowns, and multiple inlays. The scientific and clinical results are more than adequate to prove that this material has a major and substantial place in restorative dentistry. There is little to suggest that the use of hydrocolloids be decreased.

Alginates.—Like the hydrocolloids, there has been nothing new that changes the position of this material. It is logical to assume that the place of the alginates is primarily in the large impression for study casts, partial dentures, and bulk impressions. Other materials are superior to alginates for the smaller individual impressions, where precision and accuracy of detail are important. Its fragility and variables limit its use.

Synthetic Rubber Materials.—These materials have taken an increasingly prominent place in the literature and dental practice. The techniques and equipment to handle rubber that have been developed recently are noteworthy. Unreported studies of Phillips and others suggest that its accuracy is at least as good as the proved hydrocolloids. The problems with this material seem to be the establishment of generally accepted methods of handling it, and several points are crystallizing.

The products of the various manufacturers are basically the same, and little difference is noted in their accuracy. The material records extreme detail, but it must be used with inflexible trays and, when individual band impressions are made, the bands must fit loosely. Springing or yielding of the bands distorts the impressions. Several techniques have been worked out in crown and fixed bridgework which produce results that are equal, at least, to those achieved by hydrocolloid. An advantage of the rubber material is its simpler preparation. It requires

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no heat or conditioning, which is a definite advantage at the higher altitudes, and there is no need for expensive auxiliary equipment. Inadequate results with the rubber base materials appear to have been caused by the failure to understand the material and the failure to use techniques that have been proved to be necessary. Researchers and clinicians indicate, contrary to the statements by the manufacturers, that the material does distort with time and should be poured reasonably soon. However, it is not nearly as critical in this regard as are the alginates and hydrocolloids. Many good clinicians are getting excellent results with this new material and, when it is not used successfully, it seems to fail because of an incomplete understanding of the material. Synthetic rubber is encouraging a favorable trend in fixed bridgework and general restorative services.

Silicone Base Materials.—Much experimentation is now being conducted with this newest of the impression materials. Unpublished research findings suggest that this might develop into a nearly ideal material. Its accuracy may surpass even that of the rubber base materials, the alginates, and the hydrocolloids. It has qualities of toughness and stability that appear to be superior, but at present, many experienced clinicians have complained of their inability to obtain desirable casts in impressions made of this material. Investigation indicates that there may be hydrogen gas given off from the impression material for some time after it has set. This complication might be the cause of the imperfections. The difficulty that is seen in clinical application is difficult to explain, because some dentists show casts that seem to be ideal. Those who are developing the material for clinical use feel that the practical difficulties are being overcome. Certainly, the most recent developments with the silicone impression materials are eliminating the early technical difficulties, and perhaps the hydrogen gas problem has been overcome. The material holds great promise.

RESTORATIVE MATERIALS

Acrylic Resins in Prosthetics.—This material has proved itself to be rather good as a denture base and is generally accepted, although there is often undesirable warpage and distortion. Clinical experience and laboratory findings suggest techniques which are adequate, at least. There was some question about the use of acrylic resins for bridge facings and pontics, but clinical experience has not proved it to be unworthy. It has been thought that its contact with the soft tissue in the edentulous pontic area was not indicated because of chemical irritation, but during the last year, Waerhaug and Zander[1] and others have found that the tissue reaction to well-processed acrylic resins is favorable. Clinical experience also suggests that it is acceptable if it is well processed, if it is undercut into the metal sufficiently, and if it receives none of the stress of occlusion. Its color stability has been improved and now may be considered satisfactory.

SELF-CURING ACRYLIC RESINS IN OPERATIVE DENTISTRY

Our professional service is based on scientific facts; therefore, we must rely upon laboratory findings. During the last several years, we have experimented clinically with the self-curing acrylic resins as a restorative material, and our early enthusiasm has about disappeared. Clinical failures are understandable when we review the results of laboratory examinations of the self-curing resins. The National Bureau of Standards, Skinner,[2] and other investigators have agreed, rather

generally, that the material is inadequate in strength and hardness as compared to tooth structure and other proved materials. It lacks stability, and its failure to seal the average cavity condemns it. One of the prime weaknesses of the material is its extremely high coefficient of expansion, which is 7.1 times as great as tooth structure for every degree change in temperature. This compares with 2.2 for silver amalgam and less with the other restorative materials. This quality is enough to prevent any satisfactory cavity seal, and it encourages percolation which allows free entrance of bacteria into the dentinal tubules and the pulp. The material has an undesirable 7 per cent setting shrinkage and no bacteriostatic qualities. These laboratory findings should have made an unhappy and expensive large-scale clinical experimentation unnecessary. Self-curing acrylic resin's most serious inadequacy is its failure to protect the health of the pulp and the patient.

SILICATE CEMENT

Recent findings of Phillips and Swartz[3] indicate that fluorides of silicates actually combine with the enamel adjacent to the filled areas, resulting in structure that is less soluble to acid. This may be significant in future use of fluorides, which may also be well used in combination with other restorative materials.

GALLIUM

Gallium is a mercury-like metal which has been investigated by Smith and Caul[4] at the National Bureau of Standards. It is a by-product of the refining industries, but little use has been known for it. It has been suggested that it might be used to replace mercury in dentistry, but at best this is several years away. Its present cost is $2.50 to $5.00 a gram, but this could be decreased with use. It does not combine well with the present dental alloy of silver and tin, but it shows promise with nickel and cobalt. An interesting property is its ability to wet most everything, including metal instruments, matrices, and perhaps tooth structure. Its wetting property would be a disadvantage in that it would be difficult or impossible to handle by the present techniques and instruments. However, if it wets or combines with tooth structure permanently, it would be most desirable, although it is yet to be assessed biologically. It does not wet Teflon and Nylon, and it is likely that the eventual matrices and instruments must be made of these materials. This material should not be dispensed commercially until all of the questions have been first answered in the laboratory. Its physical properties can and should be evaluated by comparison with other known restorative materials. If these comparisons prove satisfactory, the material should be evaluated biologically before it is used in limited controlled experiments in the mouths of selected patients. The dental profession must follow such a procedure before any new material is used for routine treatment of patients.

GOLD FOIL

An interesting process using a new electric mallet and mat gold has been reported by Koser and Ingraham.[5] This instrument seems to have added new efficiency to a proved material. There is renewed interest in gold foil that has come about with improved cavity design and instrumentation. The trend in cavity design to extreme rather than conservative preparations is not entirely advisable.

RUBBER DAM

There is a nationwide trend to an increased usage of the rubber dam as an aid in operative dentistry. Many clinicians and teachers think this trend parallels an ascendancy in the quality of service by the profession. Since 1952, a major rubber dam producer reports an increase of 37 per cent in sales of rubber dam. Various sections of the country have been showing approximately 10 per cent increases from year to year. During the past two years, at least four dental schools have made the routine use of rubber dam an important part of treatment in their Pedodontic departments and have increased its usage in other departments. The increased usage of rubber dam in Canada, the Scandinavian countries, and our armed forces is significant.

TISSUE REACTION TO RESTORATIVE MATERIALS

Waerhaug[6] has shown the excellent tissue tolerance and cellular acceptance of gold foil. Using monkeys from which teeth were extracted, he pasted gold foil to the root surfaces of the teeth before replanting them and noted that there was a likely epithelial attachment to the foil. When bacteria were present, there was chronic inflammation. The tissue tolerance to heat-processed acrylic resin was reported to be good, but that of the self-curing resins is poor. The clinical significance of these studies is that the materials themselves, except gold foil, probably cause an unfavorable tissue reaction. This is also true for amalgam and silicate materials. We may judge that discrepancies at the margins harbor organic material and favor bacterial growth which produces inflammation and undesirable tissue reaction. Hence, regardless of the material used, there is no substitute for a perfectly beveled and well-finished margin on a restoration. This can be achieved only with the best operative procedures and with filling materials of stable and desirable physical properties.

Massler* stated that the kindest material to the dental pulp is zinc oxide and eugenol. However, calcium hydroxide has been shown to stimulate the production of secondary dentine. The original inflammation of the pulp, caused by a cavity preparation and its restoration, will usually recover and result in a healthy useful tooth. However, these results are possible only if the cavity is properly sealed from bacterial invasion at its margins.

RADIATION

Much is to be found in the literature and in popular magazines concerning the dangers of radiation. We, in the profession, have realized these dangers for many years, but discussions of radiation in the atmosphere from nuclear explosions have recently accented this hazard in the minds of our patients. There is nothing to suggest that we should not make all of the roentgenograms that are necessary (within reason) to provide a diagnostic service for the best in restorative dentistry. But, with the general hazards in mind, it is desirable that we use high-speed emulsion films, the long-cone technique, and filters to control radiation as much as possible.

THERAPEUTICS

There are several new antibiotics for dental use which are similar to those available during the last few years. It is interesting to note that as any one

*Massler, M.: Lecture at Denver Dental Association, February, 1957.

antibiotic is used, and overused, it gradually becomes less effective. A less promiscuous use of these new weapons against infectious processes would keep them more effective for a longer and greater service. Bacteria seem to have the ability to condition themselves against overused drugs and to develop new strains that produce difficult-to-treat resurgences of infections that formerly were easily controlled. Two suggestions are in order: first, diagnosis is of the utmost importance and, when possible, it should be accomplished *before* specific treatment with antibiotics is instituted; and second, it would be wise to treat easily controlled infections with other simple and adequate methods and to reserve the potent antibiotics for only those conditions which cannot be controlled otherwise.

Massler suggests, in unpublished material, that simple aphthous virus infections in the mouth can become fixed, apparently permanently, into untreatable conditions by the unnecessary and ineffective use of penicillin.

TRANQUILIZING DRUGS

During the last year, the new tranquilizing drugs have been used on a surprisingly large scale by the medical and dental professions. Their principal benefits seem to be in the treatment of mental and emotional disorders. In dentistry, these so-called "happy pills" are being used for premedication. When the hazards of overuse of any new drug or material in the treatment of the human is considered, *caution* is in order. When an extremely difficult case must be treated that cannot be handled well otherwise, the tranquilizers can be of considerable value, but there is little logic to support its general use in dentistry. The Council of Pharmacy and Chemistry of the American Medical Association informs the author that "their use may be subject to undesirable side effects or even serious toxic complications . . ." and, "casual use of tranquilizers . . . is considered medically unsound."* Also, that it has "caused massive gastrointestinal hemorrhage or perforation of an ulcer . . . and produces severe depression in a significant number of individuals and has precipitated a considerable number of suicidal attempts, some of them successful."* I suggest that, as commercial men enter our offices to introduce new products, we, as scientific men, must, in ethical fairness to our patients, always insist that their presentations be accompanied by reprints or other evidence of adequate investigation that will prove and justify any new product.

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REPORT: PART III

AN EVALUATION OF RECENT PROGRESS IN THE FIELD OF INCREASED SPEEDS AND MODERN INSTRUMENT DESIGN

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INCREASED SPEEDS FOR ROTARY instruments is one of the newest fields in dental science, and one involving the most rapid and dramatic changes in the history of the profession. It has been estimated that in 1952, just five years ago, less than 5 per cent of the profession was using increased handpiece speeds, while today the majority of the general practitioners throughout the country are employing so-called high speeds and modern instruments in some capacity. What has been the effect of this rapid transition in operative procedure? Unfortunately, there is a general feeling of confusion, indecision, and even bewilderment throughout the profession. What appears to be a practical solution to our problems today is obsolete tomorrow.

Dentistry must proceed with utmost caution in this era of so-called "Jet Engine Thinking." The mere fact that something is new and different does not necessarily make it desirable, nor does it make it right. Most certainly, not until it has been tested and evaluated for its adaptability to our use at the present time, and not until its possible hazards and disadvantages are thoroughly explored, can it be said to be desirable and right. The profession is repeatedly guilty of accepting, at face value, new materials and new apparatus described as time savers by commercial interests. Too little time is being devoted to a proper evaluation of the merits of these new products which are offered to the profession.

Without question, high speed rotary instruments offer dramatic advantages, and do contribute potentially to an increased operating efficiency. However, these advantages must be approached carefully and constructively. The dentist must have in mind the possible hazards as well as the advantages of new instruments. There should be no misconception as to the real purpose of this new approach to operative procedures. The guiding rule should *not* be how fast we can accomplish an operation. Our goal should be an improved dental health service of an increasingly higher quality, with attention directed toward the comfort of the patient and toward the conservation of time and energy for the operator.

OBJECTIVES

The following objectives are suggested as an approach to this goal:

1. The minimum number of instruments of proper shape, size, and design should be selected for each operation to be performed. Only instruments of

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highest quality should be used. There is no place for the use of unmounted stones with increased speeds. Smoothness and accuracy of operation depend upon the trueness of the instrument. Centerless ground instruments milled from a single piece of drill rod steel are available. The greater accuracy of these instruments reduces vibration and the resultant trauma to the tooth and investing tissues. Diamond instruments with coarse grit are untrue. The grit of the average dental diamond instrument is approximately 100 to 120 mesh. However, instruments of 180 to 300 mesh are strongly recommended for the intermediate ranges of speeds. Not only do they produce a smoother cut, but comparative tests employing the same work loads and speeds show that they will remove tooth structure almost as rapidly as will the coarser rotating instruments. This can be explained by the fact that with the finer mesh diamond instrument, more abrasive particles strike the tooth surface in a unit of time than will strike the tooth surface when a coarser grit instrument is employed under identical conditions.*

2. Improved methods and techniques should be employed for utilizing these instruments to the best possible advantage. This information is available in post-graduate and refresher courses as well as in the current literature.

3. Confidence and experience should be gained by practicing on extracted teeth in the laboratory before attempting to use the high speed rotary instruments and new techniques in the mouth.

Any transition in operative procedure should be approached with the utmost caution and only in the best interest of the patient. The transition should not be made solely in the interest of speed. Problems arise from a lack of familiarity and experience with instruments used under new conditions. With high speed rotary instruments, it is imperative that the approach change from the old concept of cutting and then thinking to one of thinking first and then cutting. Fundamental safeguards should be employed. The most essential of these are: (a) a firm finger rest position, (b) proper direction of rotation for the better control of the disk and wheel type instruments, and (c) visualization of the cut to be made before placing the instrument against tooth structure.

4. A range of speeds that will insure a high degree of efficiency for the instrument used, and yet, one that will not exceed the capacity of the individual dentist to adapt to these new conditions, should be employed. The decision for making this transition from one range of speeds to another depends upon the past experience of the dentist. It would be questionable judgment, for example, to make a change from 4,500 r.p.m. to 150,000 r.p.m. without first mastering the use and control of rotary instruments at intermediate speeds.

Dental operations cannot be performed with the same calculated precision as engineering procedures. The personal entities of the dentist and the patient are factors to be considered. We will not, at least in the immediate future, be operating by a table of "feeds and speeds" as is suggested by some enthusiasts in the field. We still must rely primarily upon an acute "tactile sense" to determine the required pressures and to maintain instrument control. The key to the successful employment of increased speeds and modern instruments is a constant

*Comparative studies of milling and abrading type instruments conducted in the research laboratories of the University of Southern California, School of Dentistry, 1945-1947.

and continual re-evaluation of their effectiveness in the hands of the dentist using them. Many will find that their needs will be best served by employing one of the intermediate ranges of speed, and others, with more experience, will find definite advantages in the higher speed ranges of 100,000 to 200,000 r.p.m.

Experience has shown that the conventional sleeve-bearing contra-angle and straight handpieces can be used successfully with speeds in the region of 20,000 to 25,000 r.p.m., if they are properly cared for and maintained. The ball-bearing contra-angle and straight handpieces will perform quite satisfactorily at from 30,000 to 50,000 r.p.m. There is a distinct advantage in operating in this speed range. The increased surface speeds permit the use of very small (700 size) flame and tapering bullet-nosed shapes of diamond instruments for shaping the proximal surfaces of ¾ and other veneer crown preparations. Also, the achievement of these speeds has led to the development of small tapering gingival bevelers. They are a valuable asset in the preparation of inlay and onlay type cavities. In the presence of a spray or stream of water, these stones of small diameter remove tooth structure efficiently and with only a moderate amount of pressure. When properly used, they give a remarkable length of service.

Disk and wheel type instruments provide the most efficient method for penetrating enamel and removing the initial bulk of tooth structure when intermediate ranges of speed are employed. By reason of their larger diameter, the peripheral speeds are greatly increased. Only light pressure is necessary to remove tooth structure. With the use of the very thin safe-sided proximal opening disks and occlusal opening wheels, it is possible to penetrate enamel and to establish cavity outline form efficiently and rapidly. Special techniques and procedures for the use of these instruments have been reported by Ingraham and Tanner.[1]

The ultrahigh speeds (above the threshold of vibration perception) produce a favorable patient response. While the increased noise results in some patient apprehension, this seems to be nullified to a large extent by the smoothness of cut and the absence of the usual instrument pressure. The entire approach to cavity preparation changes with these greatly increased surface speeds. Fewer instruments, and instruments of smaller diameter, can be used for shaping all parts of cavity preparations. Operating at about 100,000 r.p.m. and above requires only a light "featherlike" touch which reduces digital fatigue for the operator. However, it becomes necessary to operate with much more exactness, and a keen visual sense must be employed to safeguard against overcutting and inadvertent damage to adjacent tooth surfaces.

The ideal arrangement for a dental office is a combination of equipment, or equipment sufficiently adaptable to provide speeds in the upper and lower ranges, as well as in the intermediate range, without the disadvantage of tedious adjustment and change. A low range of speeds will always be necessary for excavating caries and for certain refining and finishing procedures. The ultrahigh speeds are, of course, more applicable to the rapid removal of bulk of tooth structure.

The possibility of untoward physiologic effects resulting from the use of ultrahigh speeds, producing vibrations above the frequency threshold of perception, has been under study at the University of Southern California, School of Dentistry. A Keeler polygraph was used to record pulse rate, blood pressure, respiratory

rate, and electrodermal response during operations on teeth with both low and extremely high speeds. In brief, this study has shown that, without anesthesia, most patients evidence changes in blood pressure, pulse rate, the rate and nature of respiration, and electrodermal reaction during operations at low or intermediate ranges of speed. There was a minimum to no response when speeds, in excess of 100,000 r.p.m., that produced vibrations above the frequency threshold of perception were employed.

COOLANTS

5. Routine procedures should include the use of a coolant and flushing stream of water to control frictional trauma. For greatest efficiency, this should be employed in conjunction with vacuum suction equipment to maintain visibility in the operating field and to conserve operating time. Work should be done by direct vision wherever possible, particularly with the "washed field technique" where visibility is impaired to some extent by fogging of the mirror.

A report by Peyton[2] indicates that air is not an effective coolant when rotary instruments the size of a number 37 inverted cone bur or larger are used at speeds above 12,000 r.p.m. and when work loads of one pound or more are employed. Also, a copious stream of water has proved to be a more effective coolant than a water spray.

6. The employment of improved and more efficient restorative procedures makes it possible to render a better health service in a shorter period of time. It, therefore, becomes imperative that attention be directed toward the principles of sound practice management. Tanner[3] has pointed out the importance of a complete oral diagnosis and treatment plan, with attention directed toward educating the patient to want and appreciate the necessary dental treatment. He has also stressed the advantages of premedication and longer appointments. These are conducive to a better health service and a better patient-dentist relationship. The psychologic effect is that the patient is not paying for a dental appointment or a filling, but for an over-all health service. The quantity and quality of dental service will not be influenced adversely by the fee.[3]

The dental profession must maintain an open mind, and each new development must be evaluated with caution and intelligence. Skill, experience, good judgment, and attention to detail are still the most necessary factors in successful dental treatment. Increased handpiece speeds and modern instruments, if mastered and intelligently applied, can be an extremely valuable adjunct to those important prerequisites.

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AMERICAN BOARD OF PROSTHODONTICS

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The 1956 examination of the American Board of Prosthodontics was held September 2-8, at Marquette University School of Dentistry, Milwaukee, Wisconsin. Fourteen candidates successfully met the Board requirements and have been certified to practice the specialty of Prosthodontics.

Dr. Vincent R. Trapozzano, president of the Board 1955-1956, retired after six years of service as an examiner. Dr. Bertram H. Downs of Colorado Springs, Colorado, was elected to the Board. Dr. Alvin H. Grunewald, Professor of Prosthodontics at Northwestern University Dental School, was elected to serve out the unexpired term of Dr. John I. Sloan who resigned from the Board because of illness.

The officers and members of the 1956 Board were Dr. Roland D. Fisher, *President;* Dr. M. M. DeVan, *Vice-President;* Dr. S. Howard Payne, *Secretary-Treasurer;* Dr. Daniel H. Gehl; and Dr. Raymond J. Nagle.

The 1957 examination of the American Board of Prosthodontics was held at the Medical College of Virginia, School of Dentistry. Fourteen candidates were successful in meeting the requirements of the Board and were certified as qualified to practice the specialty of Prosthodontics and as Diplomates of the American Board of Prosthodontics.

The Medical College of Virginia, School of Dentistry, is the host to the American Board of Prosthodontics for its 1957 examination.

Those desiring to make application for the 1958 examination should write to the secretary.

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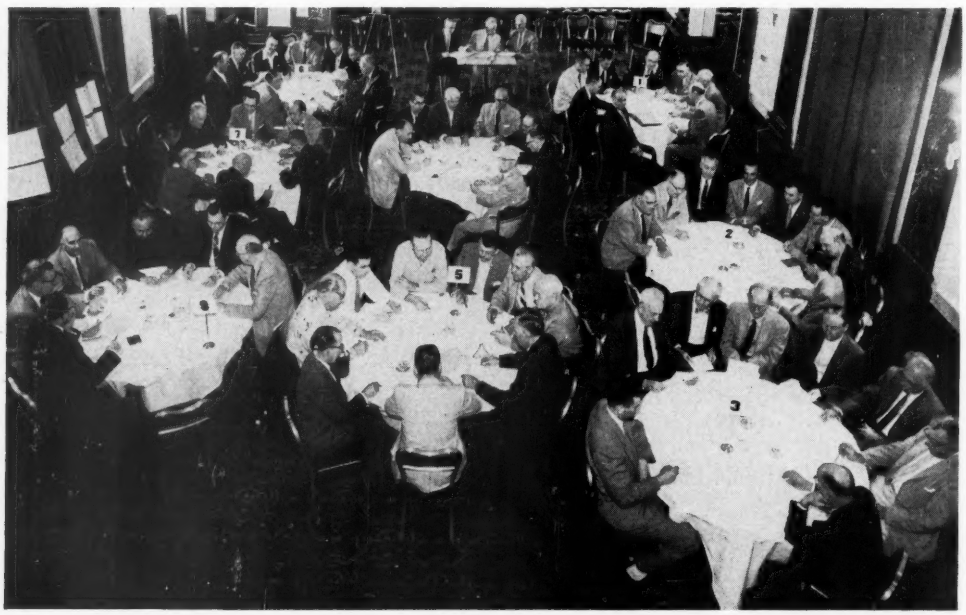

The Academy of Denture Prosthetics at work on formulating "Principles, Concepts, and Practices in Denture Service."

The originators and directors of this project, Drs. Luzerne G. Jordan, Chairman, Russell W. Tench, and Frank M. Lott are seated at the small table in the background.

The publication of the "Glossary of Prosthodontic Terms," by the Academy of Denture Prosthetics in 1956, met with such wide approval that the Academy decided to assemble the results of some of its other activities for future publication.

Probably the next release will be on "Principles, Concepts, and Practices in Denture Service." Nearly two full days of the May, 1957 meeting at Columbus, Ohio, were devoted to the various phases of formulating this report; all of the members present participated.

More than two hundred statements of concepts, principles, and practices were deliberated. Substantial agreement was reached on most of them. However, these will be further considered and tested by the Fellows of the Academy before they will be released for publication.

When this report is published, it will reflect the carefully considered opinions of most of the members of the Academy. But, as in the case of the Glossary, there is nothing fixed or final about the recommendations. The Academy plans to continue making refinements and corrections in the light of future knowledge and experience.

—Victor H. Sears

News and Notes

MEETINGS

Mid-Continent Dental Congress, Chase-Park Plaza Hotel, St. Louis, Mo., Nov. 17 to 20, 1957.

Northeastern Association of Dental Editors, Dental Writing Conference, Hotel New Yorker, New York, Dec. 4, 1957.

The purpose of this conference is to bring together dentists who are interested in writing for the dental literature. For further information write to Frederica Schneider, Secretary, Dental Writing Conference, 98-22 63rd Drive, Forest Hills 74, N.Y.

The Greater New York Academy of Prosthodontics, New York University, College of Dentistry, New York, Dec. 7 and 8, 1957.

The Greater New York Dental Meeting, Hotel Statler, New York City, Dec. 9 to 13, 1957.

American Equilibration Society, Sheraton-Blackstone Hotel, Chicago, Ill., Jan. 30, 1958.

Dallas Mid-Winter Dental Clinic, Statler Hilton Hotel, Dallas, Texas, Jan. 26 to 29, 1958.

American Denture Society, Congress Hotel, Chicago, Ill., Jan. 31 and Feb. 1, 1958.

American Academy of Crown and Bridge Prosthodontics, Conrad Hilton Hotel, Chicago, Ill., Feb. 1 and 2, 1958.

American Academy of Restorative Dentistry, Conrad Hilton Hotel, Chicago, Ill., Feb. 1 and 2, 1958.

Second Asian Dental Congress and the Asian-Pacific Dental Conference, Manila, Philippines, March 24 to 30, 1958.

American Association for Cleft Palate Rehabilitation, St. Francis Hotel, San Francisco, Calif., April 24 to 26, 1958.

This Association is composed of medical, dental, and paramedical specialists who are interested in the rehabilitation of persons with cleft lips and palates.

Academy of Denture Prosthetics, Statler Hotel, Detroit, Mich., May 5 to 9, 1958.

Fifteenth Australian Dental Congress, Adelaide, South Australia, Feb. 23 to 27, 1959.

For further information write to the Secretary, 15th Australian Dental Congress, 51 Grenfell St., Adelaide, South Australia.

ANNOUNCEMENTS

Northwestern University Dental School announces the following postgraduate courses:

Recent Advances in Medicine of Interest to the Dental Practitioner, Nov. 18 to 20, 1957.

Recent Advances in Dental Materials and Techniques, Dec. 2 and 3, 1957.

High Speed Instrumentation in Operative Dentistry, Dec. 5 and 6, 1957.

A Practical Approach to the Use of Gold Foil, Jan. 22 to 24, 1958.

Basic Oral Surgery, Jan. 27 to 31, and March 17 to 21, 1958.

Clinical Efficiency of High Speed Cutting Devices, Jan. 29, 1958.

Use of High Speed Instrumentation and Its Effect on the Dental Tissues, Jan. 30 and 31, 1958.

Thomas L. Gilmer Memorial Lecture, Feb. 19, 1958.

Endodontics, Feb. 24 to 26, 1958.

Major Oral Surgery, March 10 to 14, 1958.

Use of Elastic Impression Materials, March 31 to April 2, 1958.

Complete Denture Procedures in General Practice, April 2 to 4, 1958.

Prosthetic Rehabilitation for the Cleft Palate Patient, April 7 and 8, 1958.

Clinical Features of Oral Lesions, April 16 to 18, 1958.

Edmund Noyes Memorial Lecture, April 23, 1958.

The Use of Drugs in Dental Practice, April 30 to May 2, 1958.

Diagnosis, Roentgenography, and Treatment Planning, May 5 to 7, 1958.

Conference for Teachers of Pedodontics, June 9 and 10, 1958.

For further information and application write to Director of Dental Postgraduate Study, Northwestern University Dental School, 311 East Chicago Ave., Chicago 11, Ill.

The University of Pennsylvania, School of Dentistry, announces the following postgraduate courses:

Periodontal Therapy, Dr. Henry M. Goldman and Dr. D. Walter Cohen, Dec. 16 to 20, 1957.

Complete Dentures, Dr. Vincent R. Trapozzano, Dec. 16 to 21, 1957.

Oral Diagnosis and Roentgenology, Dr. Lester W. Burket and Dr. LeRoy M. Ennis, Jan. 13 to 17, 1958.

Prosthetic Relations of the Temporomandibular Joint, Dr. Ernest R. Granger, Jan. 13 to 17, 1958.

For further information write to Postgraduate Courses, School of Dentistry, University of Pennsylvania, 4001 Spruce Street, Philadelphia 4, Pa.

The Medical College of Virginia, School of Dentistry, announces the following postgraduate courses:

Crown and Bridge Prosthodontics, Feb. 17 to 19, 1958.
Partial Denture Design, Feb. 26 to 28, 1958.
Complete Denture Construction, March 3 to 8, 1958.
Oral Diagnosis, March 10 to 14, 1958.
Anatomy of the Head and Neck, March 17 to 21, 1958.
Oral Surgery, March 31 to April 2, 1958.
Periodontology, April 14 to 16, 1958.
Roentgenology, April 21 to 23, 1958.

For further information and application write to Dr. H. T. Knighton, Medical College of Virginia, School of Dentistry, Richmond 19, Virginia.

Tufts University School of Dental Medicine announces the following postgraduate refresher courses:

Oral Medicine—Diagnosis and Treatment of Oral Diseases, Nov. 25 to 27, 1957.

Complete Denture Implants, Jan. 6 to 10, 1958.

Orthodontic Principles of Interest to the General Practitioner, each Wednesday for eight weeks from Feb. 5 to March 26, 1958.

Oral Pathology for the Oral Surgeon, each Thursday afternoon for ten weeks from Feb. 6 to April 10, 1958.

Occlusal Equilibration, Feb. 10 to 12, 1958.

Periodontics, Feb. 26 to 28, 1958.

Crown and Bridge Prosthesis Participation Course, Feb. 28, March 1, 7, 8, 14, 15, 22, 29, 1958.

Participation Course in Periodontology, April 14 to 18, 1958.

For further information write to Director of Graduate and Postgraduate Studies, Tufts University School of Dental Medicine, 136 Harrison Ave., Boston, Mass.

Tufts University School of Dental Medicine also announces two research fellowships in Oral Pathology and Periodontology which are intended for graduate dentists interested in research and teaching careers in oral pathology and periodontology. The fellowships offer training in oral pathology in a laboratory with an active biopsy diagnostic service, and an opportunity for preparing for advanced degrees.

Additional information may be obtained from Dr. Irving Glickman, Department of Oral Pathology and Periodontology, Tufts University School of Dental Medicine, 136 Harrison Ave., Boston, Mass.

Applications for internships and residency at the Dental and Oral Surgery Service of the Mount Sinai Hospital should be made as soon as possible. For further information write to Dr. Max Fuchs, Assistant Director, The Mount Sinai Hospital, 11 East 100th Street, New York 29, N. Y.

The University of Alabama, School of Dentistry announces the following refresher courses:

The Theory and Practice of Periodontics, Nov. 16-18, 1957.

Histopathology of the Periodontium, Nov. 19-23, 1957.

Dental Assisting, Nov. 23, 24, 1957.

Emergency Care in Dental Practice, Nov. 30-Dec. 2, 1957.

Laboratory Techniques, Dec. 7, 8, 1957.

Practical X-ray Technique and Interpretation, Dec. 9-13, 1957.

High Speed Techniques in Operative Dentistry, Jan. 3-5, 1958.

Treatment Planning and Case Presentation, Jan. 11-13, 1958.

Immediate Root Canal Therapy Followed by Apicoectomy, Jan. 16, 17, 1958.

The Management of Pain in Dental Practice, Jan. 25, 26, 1958.

Nutrition and Dentistry, Feb. 1-3, 1958.

Effective Speaking for Professional People, Feb. 4, 6, 11, 13, 18, 20, 25, 27, 1958.

English for Professional People, Feb. 5, 12, 19, 26, March 5, 12, 19, 26, April 2, 9, 16, 23, 30, and May 7, 14, 21, 28, 1958.

Periodontology for the General Practitioner, Feb. 8-10, 1958.

Preventive Orthodontics, Feb. 15-17, 1958.

Laboratory Procedures in Crown and Bridge Prosthesis for the General Practitioner, Feb. 22-24, 1958.

Occlusal Adjustment: Its Relation to Dental, Periodontal, and Temporomandibular Joint Problems, March 1-3, 1958.

Insurance, Investments, and Estate Planning, March 4, 5, 1958.

Income Tax Guidance, March 6, 1958.

Applied Maxillofacial Anatomy, March 8-10, 1958.

Practical Exodontia, March 29-31, 1958.

Root Canal Therapy, April 12-14, 1958.

Pedodontics for the General Practitioner, April 19-21, 1958.

Complete Denture Prosthesis, May 4-6, 1958.

Management of Infections in Dental Disease, May 10-12, 1958.

Surgical Anatomy of the Head and Neck, May 17-19, 1958.

Etiology and Diagnosis of Pain of Dental Origin, May 20, 21, 1958.

Removable Orthodontic Appliance Construction, May 24-26, 1958.

For further information and application write to Dr. Arthur H. Wuehrmann, University of Alabama, School of Dentistry, Medical Center, Birmingham 3, Alabama.

Emory University, School of Dentistry, announces the following postgraduate courses:

Minor Tooth Movement, Dr. Frank F. Lamons, Dr. Charles H. Smith, and Staff, Dec. 4 to 6, 1957.

Occlusion, Dr. Sigurd Ramfjord, Feb. 3 to 7, 1958.

Posterior Crown and Bridge Prosthodontics, Dr. George H. Moulton and Staff, March 5 to 7, 1958.

Pedodontics, Dr. Ralph L. Ireland and Staff, April 23 to 25, 1958.

Refresher Course in Immediate Denture Prosthesis, Dr. L. B. Brown, Dr. H. J. Harpole, Dr. J. C. Garland, and Dr. Parker E. Mahan, May 8, 1958.

Periodontia (Participation Course), May 19 to 23, 1958.

For further information write to Emory University, School of Dentistry, 106 Forrest Ave., N.E., Atlanta 3, Ga.

Temple University School of Dentistry announces the following postgraduate courses:

Complete Denture Construction, Dr. Bernard Jankelson, Jan. 6 to 10, 1958.

Rehabilitation of the Edentulous Patient, Dr. Bernard Jankelson, Jan. 13 to 18, 1958.

Advanced Orthodontics, Dr. Robert H. W. Strang, Jan. 19 to Feb. 1, 1958.

Periodontal Prosthesis, Dr. Morton Amsterdam and Dr. Walter Cohen, Feb. 10 to 14, 1958.

Practice Administration, Dr. Jay H. Eshleman, Feb. 15, 1958.

Practical Uses of Electrosurgery in Dentistry, Dr. Maurice Oringer and Dr. Martin Entine, March 1, 1958.

Oral Medicine, Dr. Leonard Rosenthal and Dr. Lester Burket, March 3 to 7, 1958.

Advanced Surgical Techniques in Periodontal Therapy, Dr. Saul Schluger, April 21 to 25, 1958.

The Washed Field Technique in Accelerated Dentistry, Dr. E. O. Thompson, May 5 and 6, 1958.

Endodontics—Immediate Root Resection, Dr. Louis Grossman and Dr. Leonard Parris, June 3 to 7, 1958.

The Porcelain Jacket Crown, Dr. Joseph Ewing, June 11, 12, 18, 19, and 25, 1958.

For further information and application write to Dr. Louis Herman, Postgraduate Division, Temple University School of Dentistry, 3223 North Broad Street, Philadelphia 40, Pa.

The Ohio State University, College of Dentistry, announces the following postgraduate courses:

Complete Denture Prosthodontics, Dr. Carl O. Boucher, Nov. 18 to 22, 1957, and Feb. 17 to 21, 1958.

Endodontics, Dr. J. Henry Kaiser, Jan. 13 to 17, 1958.

Review of Dental Hygiene (For Hygienists), Staff, Jan. 27 to 29, 1958.

Crown and Bridge, Dr. Thomas F. McBride, Feb. 10 to 14, 1958.

Partial Denture Prosthodontics, Dr. Victor L. Steffel, Feb. 24 to 28, 1958.

Pedodontics, Dr. Lyle S. Pettit and Dr. Benjamin H. Williams, March 3 to 7, 1958.

Oral Pathology, Dr. Hamilton B. G. Robinson, March 10 to 14, 1958.

General Anesthesia, Dr. Morgan L. Allison, April 28 to May 2, 1958.

Periodontics, Dr. John R. Wilson, May 5 to 9, 1958.

Review of Clinical Dentistry, Staff, May 12 to 16, 1958.

Pharmacology, Dr. William R. Kampfer, May 19 to 23, 1958.

For further information and application write to Postgraduate Division, The Ohio State University, College of Dentistry, Columbus 10, Ohio.

The Rowe Smith Memorial Foundation will hold its Fourth Annual Seminar at Fly-n-Fish Lodge, Caddo Lake, Karnack, Texas, Dec. 8 to 11, 1957. The subject of this seminar will be "Wound Healing." For further information, write to Rowe Smith Memorial Foundation, Inc., 501 State National Bank Building, Texarkana, Arkansas-Texas.

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er New York Academy of Prosthodontics Meeting, New York, New York, December 7 and 8, 1957

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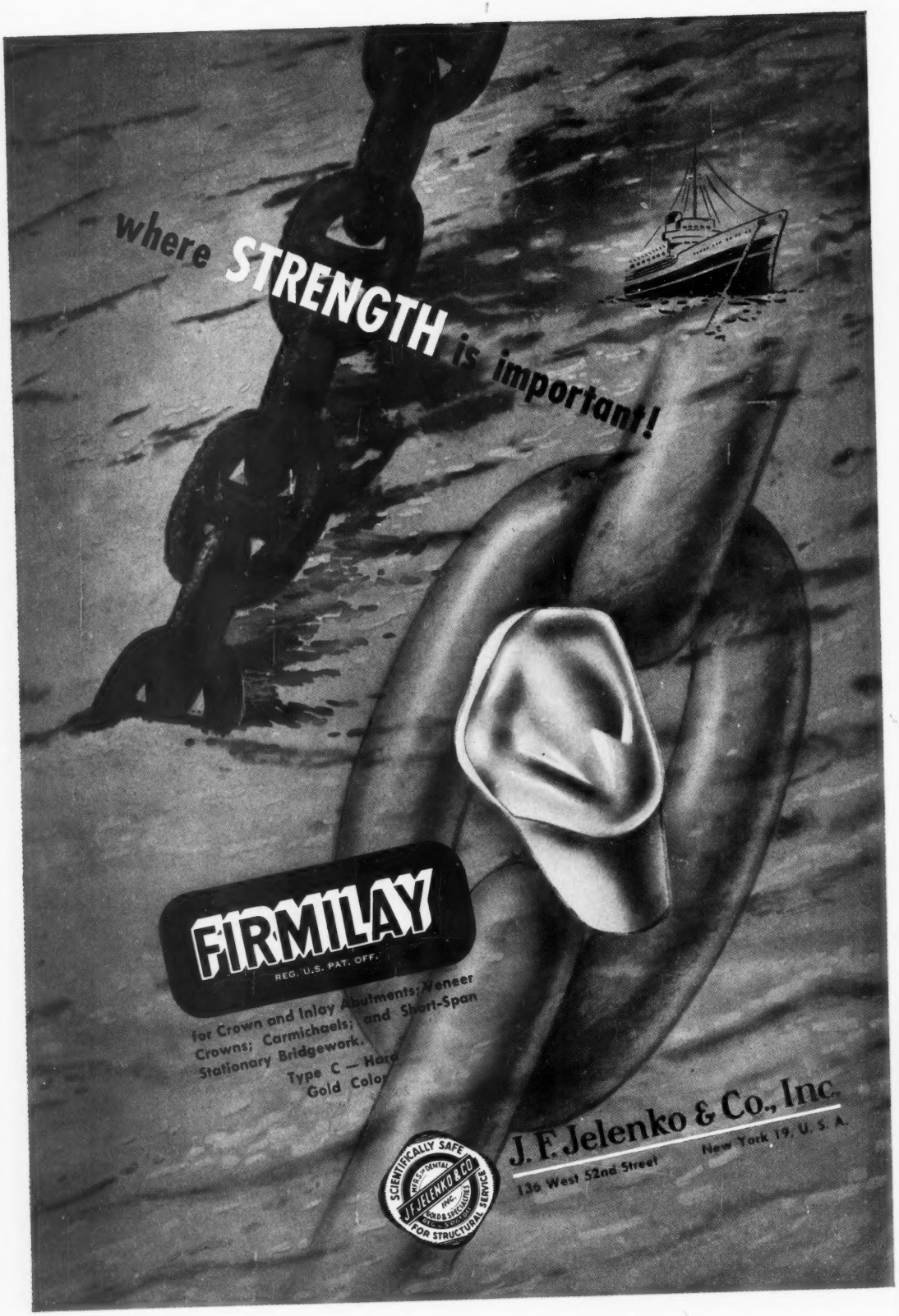
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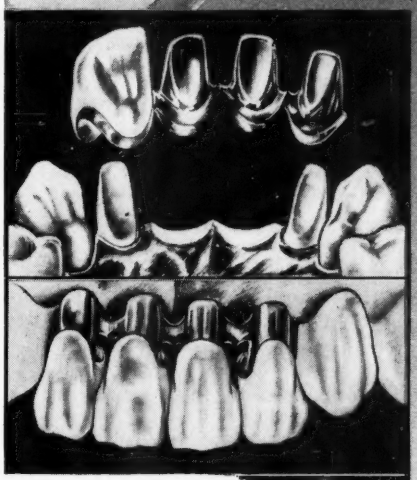

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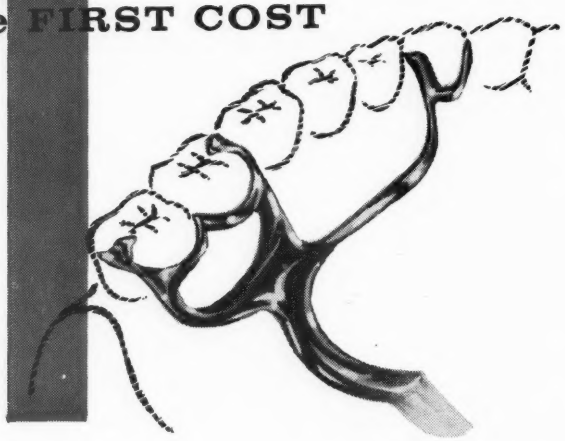

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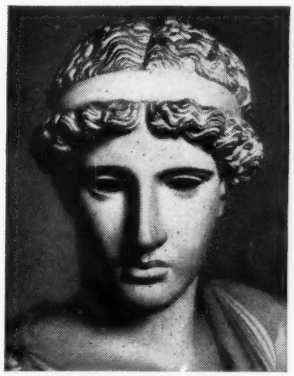

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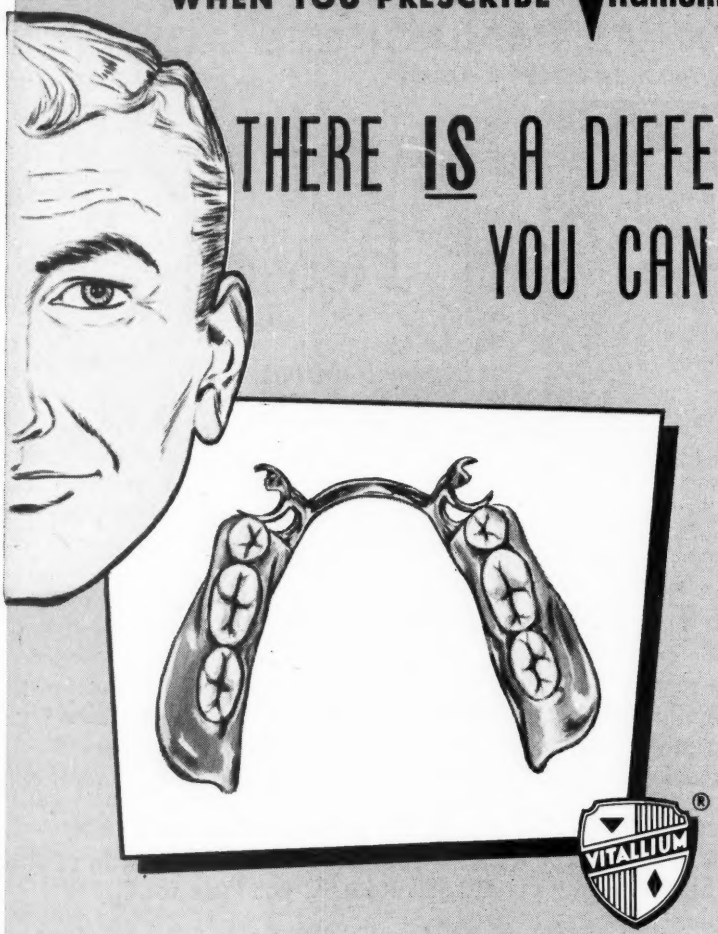

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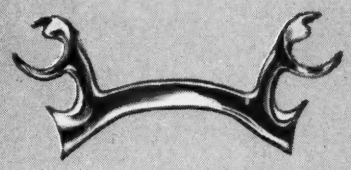

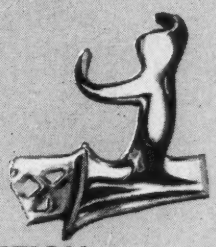

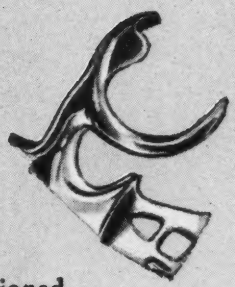

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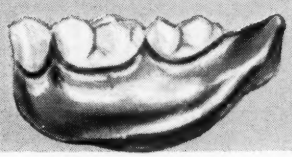

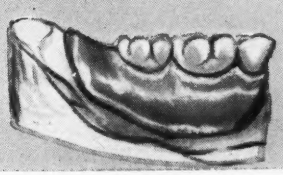

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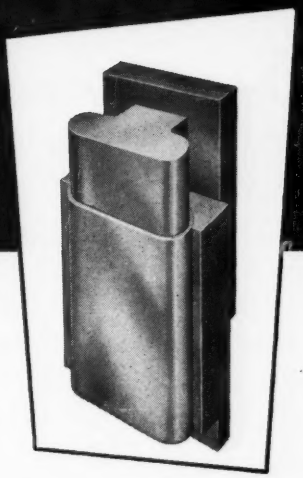

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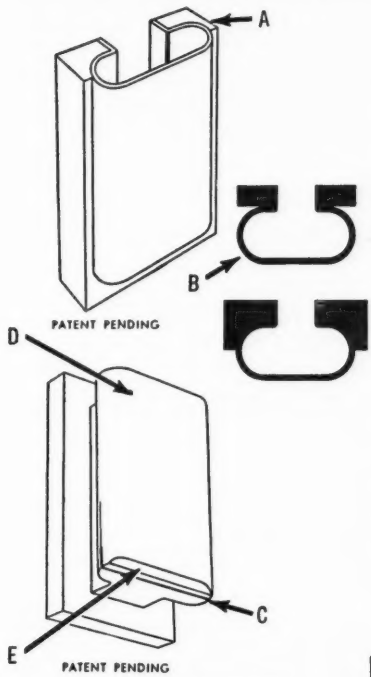

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Review

February 1956, Richard L. Myerson reported to the American Academy for Plastic Research in Dentistry his finding of dramatic reduction in wear of plastic teeth when opposed to properly designed porcelain teeth. November 1956, Victor H. Sears and Simon Myerson reported remarkable success in forty-eight clinical test cases. At the time of this writing, thousands of full dentures have been made with Myerson and Sears porcelain-plastic posterior teeth by the profession-at-large. There can be no doubt that this use has been extensive enough to be highly conclusive.

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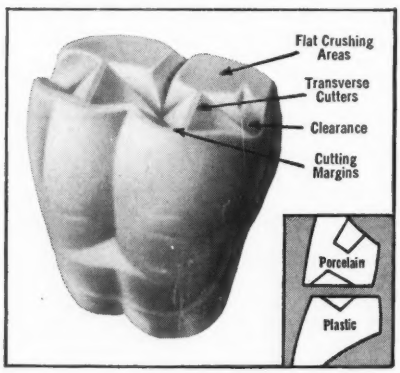

Details of occlusal construction of new Myerson and Sears posterior teeth. Insert drawing shows how upper and lower teeth meet in one plane.

Conclusion

Many benefits can be derived from the use of Myerson and Sears posterior teeth. They are listed below.

I Benefits of Opposing Porcelain Teeth to Plastic

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4. Increased stability by absence of interdigitating cusps.
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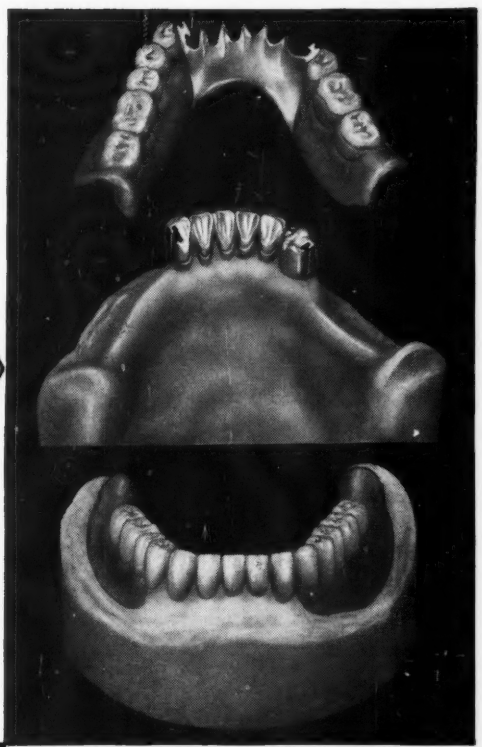

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Emphasis has been placed upon diagnosis and treatment planning.

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1. Diagnosis, Prognosis, and Treatment Planning ..... 18 pages
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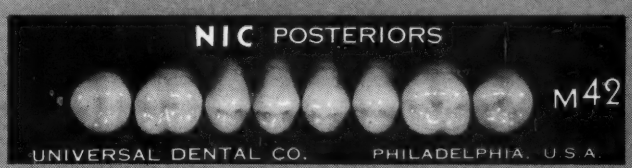

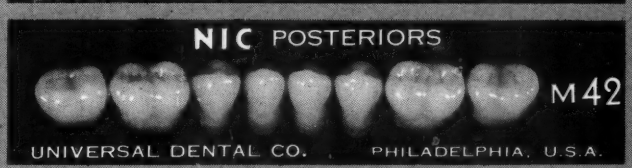

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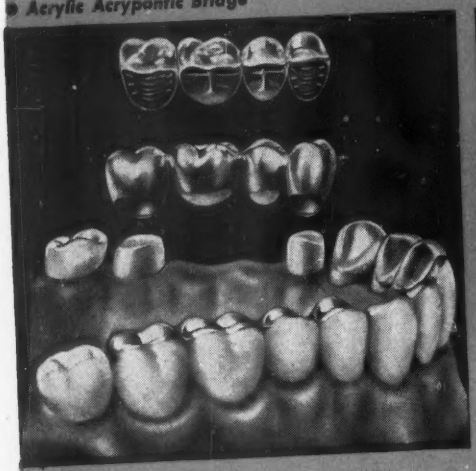

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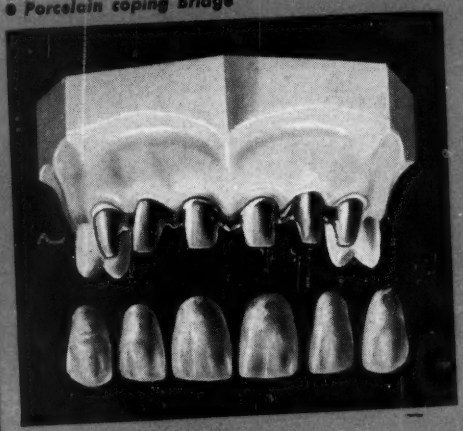

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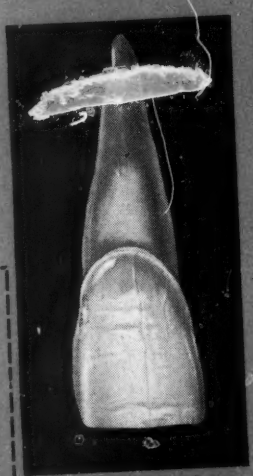

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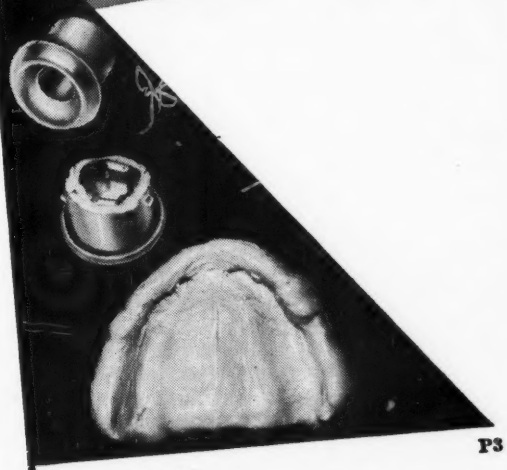

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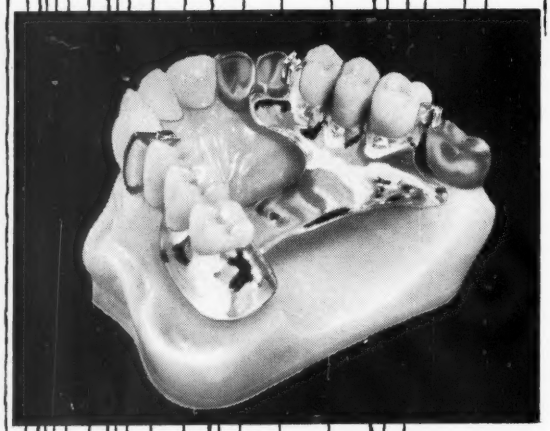

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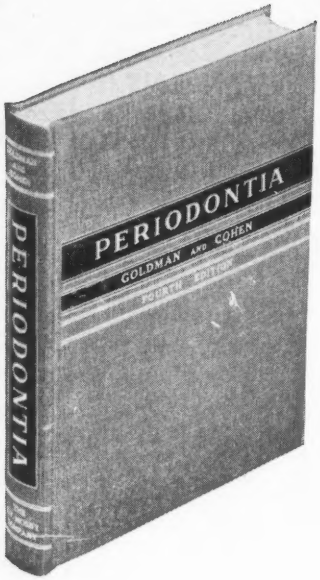

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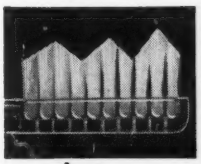

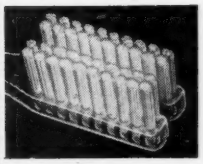

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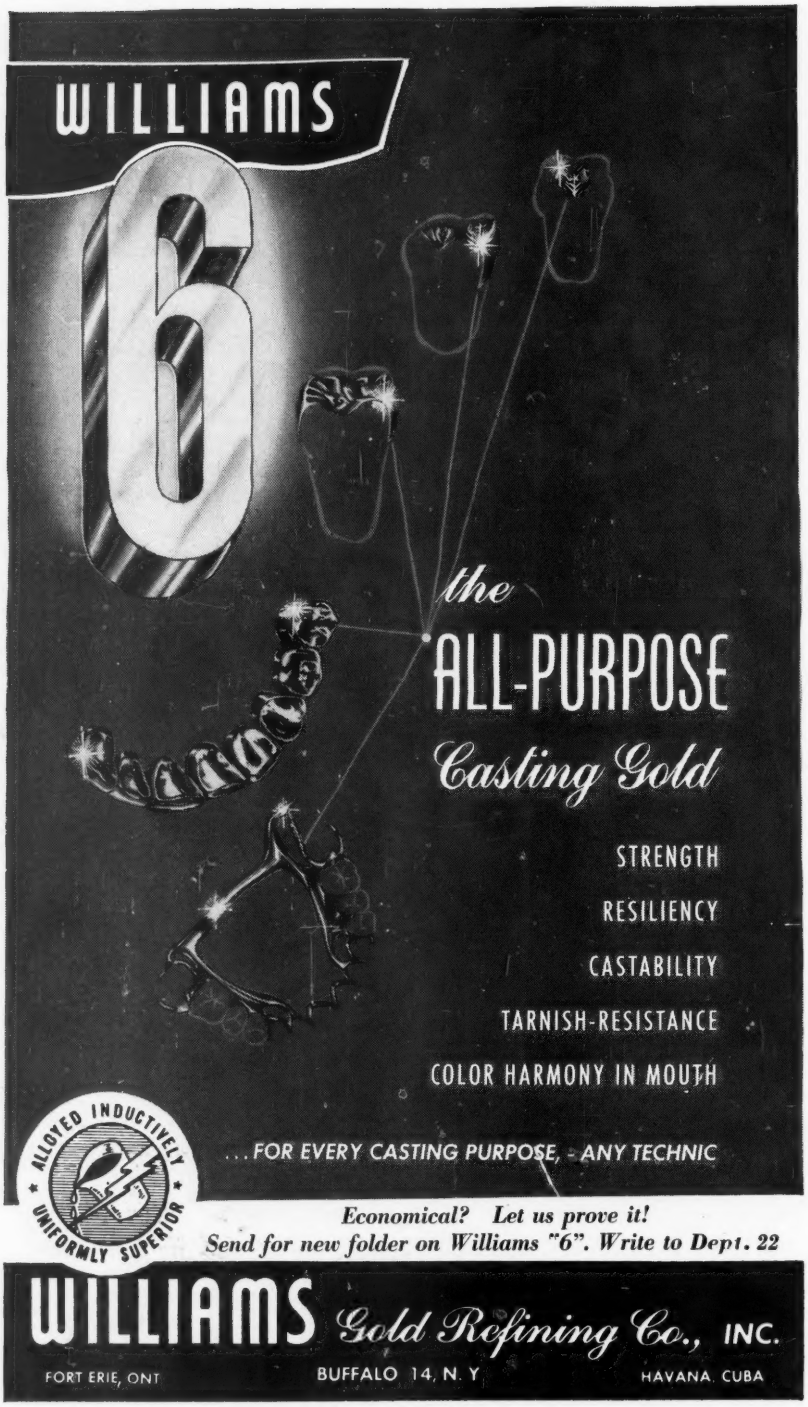
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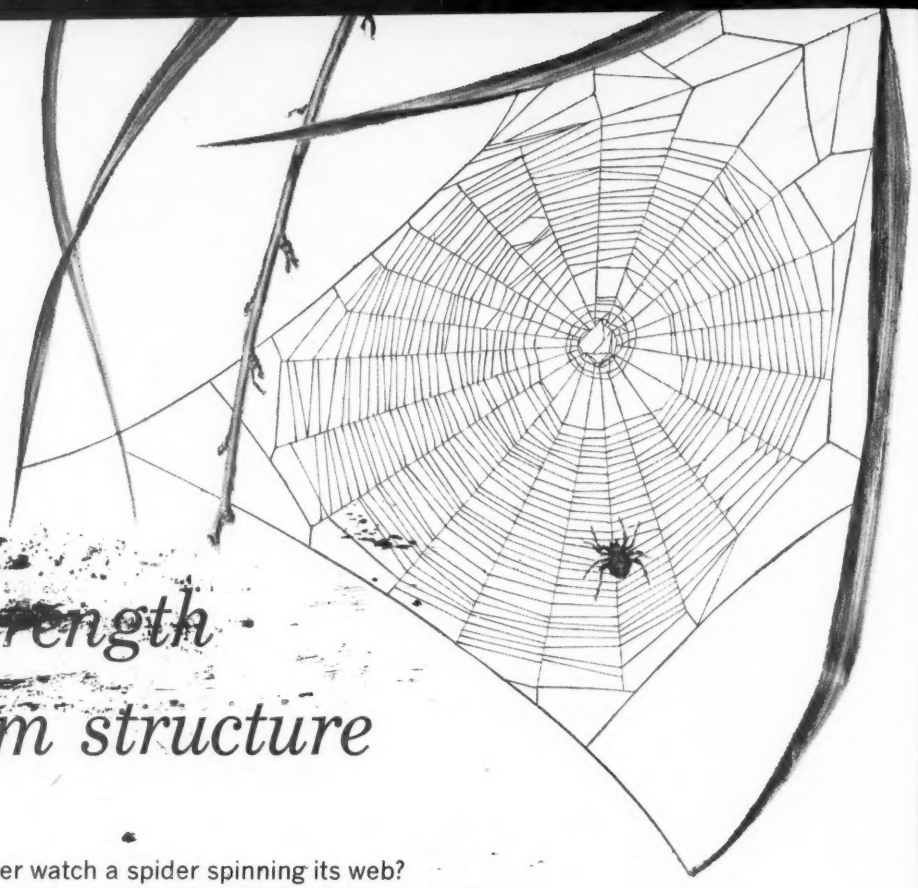

strength from structure

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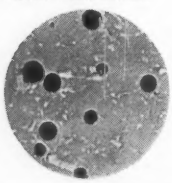

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